APPENDIX A

Survey Plan

Plan for Surveying Maritime Experiences in Reduced Workload and Staffing

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1.0 INTRODUCTION

1.1 Background

The overall objective of this plan is to support the development of an optimized staffing strategy for the Coast Guard's Deepwater Project (DWP). Optimized staffing is the minimum crew level for a ship consistent with human performance and safety requirements, technology availability, affordability and risk. Optimized staffing also encompasses optimized crew performance, workload, and safety. Optimized crew performance means that each crew member, acting alone or in a team, will be capable of performing all tasks as required, to the required accuracy and throughput, and within time constraints, in all expected mission conditions. Optimized workload refers to the level of sustained workload which will not lead to human errors, either through fatigue or boredom. Optimized safety means zero accidents.

The effort is comprised of four tasks, as follows:

Task A. Literature Search. The objective of this task is to the state of knowledge concerning ship staffing in the published and unpublished literature for government and merchant fleet acquisition programs worldwide.

Task B. Survey plan. The objective of this task is to publish a survey plan which is designed so as not to replicate readily available, and applicable, information identified in Task A, above. This plan has been generated in response to Task B, and details: the means by which surveys will be performed; how information collected will be analyzed; how alternate manpower reduction strategies for the DWP will be developed, and; estimates of the level of workload/crew reduction that may be realized for each strategy, if adopted and implemented by the DWP.

Task C. Survey Successful Manpower Reduction Programs. The objective of this task is to implement the plan generated in Task B and identify specific characteristics, approaches, and lessons learned from successful crew reduction programs. Successful programs are defined as those that resulted in manpower reductions of at least 15% and is at least 3 years old.

Task D. Identify the Impacts of Staffing and Maintenance Strategies on Life Cycle Costs. The objective of this task is to identify the impact on life cycle cost of the crew and maintenance strategies identified by the Coast Guard as being viable for the Deepwater Surface Platform

The basic approach reflected in this plan is to examine already implemented workload and manpower-reducing efforts of maritime fleets (commercial and US and foreign Navies), assess their success at workload and crew reduction, and identify potential approaches that may be adopted by the DWP. Existing crew reduction efforts will be assessed according to:

Strategies employed to reduce workload and crew

- Effects of those strategies on mission effectiveness and safety
- Costs of implementation
- Life-cycle costs of reduced crew platforms
- Applicability to the DWC program
- Implications of crew reduction techniques on human and system performance.

1.2 Issues

Reducing crew on ships at sea typically involves three components:

- Application of automation technology
- Modification of operational and maintenance procedures and protocols
- Imposition of new skill, knowledge, and abilities (KSAs) on the crew, which in turn impose new training requirements.

In addition, as part of the design process, tradeoffs are made that significantly influences the ship and it's performance. These represent issues that must be addressed in the design of reduced crew for the DWC. These encompass issues related to:

- Cost
  - R&D
  - Acquisition and implementation
  - Logistics and life cycle support
  - Decommissioning
  - Personnel (by rating, paygrade, series)
- Performance
  - Operational changes
  - Shore infrastructure
  - Readiness
  - Reliability
  - Maintainability
  - Safety
- Personnel
  - Readiness
  - Fatigue
  - Training

Since many fleets have experience with reduced crew, their experiences will be surveyed.

1.3 Objectives of the Research/Survey Plan

The objectives of this research/survey plan are to:

- Develop the tools and a schedule for conducting surveys of maritime organizations that have established workload and crew reductions for ships at sea.
- Apply the surveys at a total ship and ship function level
- Assess the information in the context of a matrix of functional areas by issues.
- Identify concepts for crew reduction that are applicable to the DWC.
- Database the information in a form such that a tool (under Task D) can be used to support the cost assessment and tradeoff process in the design of the DWC.

The survey instrument will address manpower and workload reduction that has been achieved for overall ship crew, and for crew/workload reduction in specific ship functional areas. These specific areas are presented in Table 1, below:

Table 1. Functional Areas for Reduced Crew Surveys

Mission Operations	**Special Operations**
Boat Handling/Boarding	Underway Replenishment
Area Surveillance	Electrical Failure
Communications - Internal	Extreme Weather
Communications - External	Fire - Large and Small
Weapon and /Combat Information	Flooding/Ballast control
Helicopter/UAVs	Collision/ Grounding/ Stranding
NOAA/Weather services	Internal Security
Oceanographic	Loss of Propulsion
SAR	Search and Rescue
Deck Operations	Boarding/Law Enforcement
Anchoring	Anti-Terrorism
Docking Undocking	Man Overboard/Rafters
Helo Operations	Fuel Spills/Environment Hazards
Boat operations	Lifeboat
Line Handling/Mooring	**General Operations**
Anchor	Bridge - Housekeeping
Towing Operations	Bunkering
Underwater Lighting	Deck Equip Maintenance

Table 1. Functional Areas for Reduced Crew Surveys (continued)	
Navigation/Bridge	Direct Shore Gangs
Approach Berth	Docking/Undocking
Berthing	Line/wire Maintenance
Collision Avoidance	Medical
Depart Berth	Stores Breakdown
Hull Performance/Station Keeping	Steering Gear Maintenance
Maintenance	Stores Handling/Breakdown
Maneuver	Structure Maintenance
Lookouts	Wash down - Deck
Signals	Wash down - Engine
Position Fixing	**Administration**
Record/chart Keeping	Reporting
Track Keeping	Health Care
Voyage Planning	LAN Maintenance
Weather Monitoring	Finance/Payroll
Hotel/Unit Support	Ships Meetings
Catering/Messing	Mission Planning
Laundry	**Shore Operations**
Provisioning	Stores loading
Space Cleaning	Port Logs/Records
Waste Disposal	**Maintenance - Ship area**
Maintenance - Overview	Vital Systems Test
Maintenance Philosophy	Equipment Surveillance
Depot/Shoreside	Computers
Intermediate	Electric System
Hull	Evaporators
Unit	Fuel Oil
Training and Personnel Support	Fuel Transfer
Off ship and Schools	Generators
OJT	Inert Gas
Cross training	Propulsion
Engine and Auxiliaries Operations	Pumps/Valves
Record Keeping	Tools/Test Equipment
Routine Operations	Communications
Watch Standing	Boat Maintenance
	HVAC
	Housekeeping (common and rec areas)

2.0 METHOD/APPROACH

The approach to perform the reduced crew surveys is described below and presented as Figure 1.

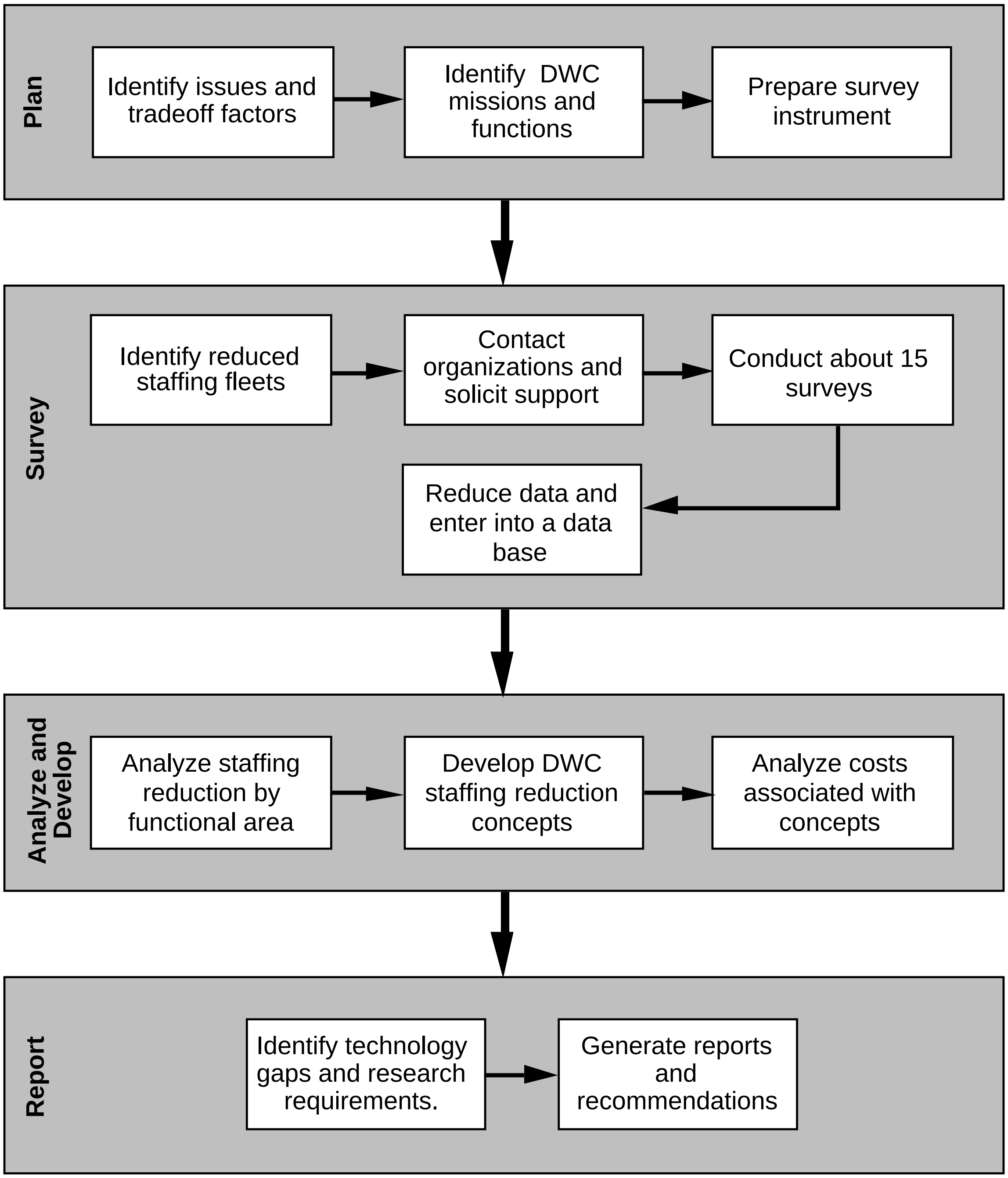

Figure 1. Survey Task Process

2.1 Survey Activities

The survey consists of two parts. The first is a summary that establishes an overview of the missions, operations and maintenance characteristics of the ship(s) with reduced crew. It is intended to capture the typical elements of life-at-sea aboard the ship under review. Specifically, this portion of the survey summarizes:

- Total ship crew
- Overall staffing/crewing philosophy
- Missions
- Environments
- Watch Standing and Duty Stations
- Staffing Philosophies and Crew sizes
- Normal and special operations and evolutions
- Support functions
- Maintenance (unit, intermediate, depot)
- Training (on board)
- Applications of automation
- Emerging technologies.

This portion of the survey is estimated to require about one hour to complete. The data collection form for this portion of the survey is presented in Attachment A.

The second part of the survey addresses strategies associated with reduced crewing by functions (see Table 1).

Each item presents a summarizing statement of the issue or topic, and then solicits comments from participants concerning issues related to:

- Organizational experience related to issue, including safety, cost, system performance and effectiveness
- Work reducing technologies or approaches, addressing what has been tried in order to reduce workload, including application of automation, reallocation of functions, and redesign of procedures and policies.
- Evidence of success or failure of approaches, and methods/metrics by which success or failure has been assessed. Soft measures (such as "crew morale), as well as hard measures (such as cost) will also be solicited.
- Costs associated with reducing workload or manpower, including RDT&E costs, acquisition costs, and support cost data will be solicited.

There are potentially many observations that could be made using these forms, however, only those functional areas that are relevant to a particular fleets reduced crew effort will be surveyed. For example, if a fleet operator has no specific activity related to reduced workload or crewing in the Environmental safety function, then no survey forms will need to be completed for that function.

From the above, workload and crew reducing strategies will be identified, efficacy of each will be assessed based on user group experiences, and cost factors identified.

The data collection form for this portion of the survey is presented in Attachment B.

2.2 Survey Schedule and Milestones

The specific schedule for completion of surveys will evolve based on the schedules and availability of the participating organizations. The overall schedule for the project is presented below.

Tasks	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Task A. Literature Search		———	———Δ				
Task B. Research Plan	———	———	Δ				
Task C. Survey			———	———	———	Δ	
Task D. Cost Analyses				———	———	Δ	
Final Report					———	———	Δ

2.3 Participation

This section addresses government and contractor responsibilities in the application of this research/survey plan. Section 2.4 addresses the expected participation from ship operators (industry and government).

At least two project personnel should be present during the conduct of each survey, at least one of which must officially represent the USCG. Others can be representatives of either the contracting organization or the USCG.

2.3.1 Government. A cognizant spokesperson from the USCG is required to:

- Provide support gaining cooperation from management of reduced manned fleets (commercial or military), particularly in soliciting commercial or other sensitive information (related to cost, proprietary designs, and perhaps security classifications).
- Submit formal requests for participation of reduced crew ship organizations under USCG letterhead.
- Provide liaison among the contractors, the USCG and representative of reduced crew fleets (foreign and domestic, military and commercial).
- Participate in the conduct of all surveys in order to: preserve project memory; support real-time issue resolution, and; support evaluation of reduced crew concepts that result from the information attained in the interviews

2.3.2 Contractor. Contractors are responsible to:

- Generate the survey plan (this document)
- Identify potential survey participant (underway)
- Provide direct support in collecting reduced crew information by participating in application of survey instruments
- Input and maintain the information obtained
- Maintain contract files, including any Non-Disclosure agreements that may be needed to entice organizations to participate.
- Analyze the survey data
- Develop crew reduction strategies/concepts for the DWP
- Identify cost factors associated with each concept
- Assess life cycle cost impacts for the DWP for each concept.

2.4 Sources of Information

Approximately 15 organizations with an established history of ship operation with a reduced crew size are being identified. Each organization will be contacted and requests made to secure and schedule participation in this survey. Criteria for selecting potential candidates are as follows:

- Must have operated ships with a crew reduction of at least 15%
- Must have a minimum of three years operating experience with a reduced crew size.

In person interviews, using the survey instrument, will be conducted. In each session, the following types of personnel will be asked to be present:

- Shore support or management - this included commercial operators/agents or base support personnel for military ships.
- Ship management - this includes a reduced manned ship officer (military) or Master/Mate (commercial).
- Working crew - Chiefs or petty officers for military vessels, or licensed mariners for commercial ships. Based on the main whip areas where crew reduction has be achieved (command/control, surveillance, engineering, etc.) requests for specific rates to support the interview/survey process will be made.

In all interviews, either a shore management representative or a ship manager must be present to support the interview. Surveys cannot be completed using working crew only.

Table 2, below presents a logging form where participation in the survey will be documented. The website http://carlow.com contains this form with cell filled in documenting contact history.

Table 2. Reduced Crew Survey Contact Log Form

Organization	Point of Contact	Contact Log and Schedule
Organization name	POC	Initial Contact: Materials sent: Survey Date: Survey Place: Survey Conduct: Follow up:
Organization name	POC	Initial Contact: Materials sent: Survey Date: Survey Place: Survey Conduct: Follow up:
APL		Etc.

2.4.1 Protocol for Soliciting Participation

The protocol for soliciting participation will be as follows:

- Identify candidate organizations for participation
- Identify, in each organization, cognizant personnel as initial Points-of-Contact.
- Make initial voice contact:
  - Introduction, state nature of request for participation and summarize study objectives
  - Guarantee information privacy. Offer, if needed, to sign Non-Disclosure statement.
  - Provide USCG points-of-contact for verification of request and identification of contract personnel
  - State information required/requested of participant

- State that interviews will be recorded (unless the participant objects) and that participant observations will be entered into an electronic database during the course of the interviews.
- Estimate support required by participants (personnel needed, for how long, and when and where needed)
- Request surveys be conducted at the participants location, preferably aboard the reduced crew level ship.
- Promise information package to be forwarded to participants, submitted under USCG letterhead and signature.
- Point person to URL containing additional information and a summary of what is required in this plan [under development]
- Get agreement from organizations management to participate.

• Follow-up with postal mailing from USCG, under USCG letterhead, and telephone contact from USCG.

• Follow-up with voice contact, arranging schedules, meeting places, and related details of participation.

• Modify project schedules

2.4.2 <u>Protocol for Conduct of Survey/Interviews</u>.

All interviews will be recorded. Data will be collected using the forms contained in Appendices B and D, or completed using internet front end to a database.

The procedure for conducting the interviews will be as discussed in Table 3:

Table 3. Protocol for Conduct of Surveys

Step	Personnel Responsible
Meet at the arranged time and place.	all (USCG, contractors, participants)
Make introductions	USCG
Verify that the right people are attending • Contractor: data analyst, data entry clerk • USCG team leader • Participant: management representative, ship management (officer or mate), and optionally crewmember (noncom or certified)	Contractor

Table 3. Protocol for Conduct of Surveys (continued)	
Summarize objectives, schedules, and information requirements.	USCG or Contractor
Set up and verify recording equipment: video or tape, and laptop (or other computer) for typed entry.	Contractor
Begin with the overview survey (about one hour)	Contractor
Complete the detailed survey (up to six hours	Contractor
Once done, verify that surveys are complete	Contractor
Identify and document any open items or action items (what - who - when)	All
Arrange for follow-up conversations	All

2.5 Data Analysis and Concepts

The objective of this task is to specify the means by which survey information will be stored, and how reduced crew concepts will be generated.

2.5.1 Data Storage. All survey data will be entered into a flat data base, using Filemaker Pro version 4.0 as the data-basing program. This program will be used since (1) it is multi-platform (Macintosh and Intel machines), (2) it can generate output to numerous database interchange formats, and (3) it is internet publishable, updateable, and searchable.

2.5.2. Reduced Crew Concept Development.

The surveys are targeted at identifying manpower reducing techniques that have been imposed in ship design and that have a history ship operational use. Total ship crew reduction results from:

- workload reductions at the level of the function (automation and procedures)
- integration and synthesis of new functional requirements with new allocations to individual crew members (deriving total staffing)
- development of total ship procedures, protocols and doctrine, and
- new training and certifications of those new crewmember allocations.

Development of a total ship crew concept requires, therefore, the development of a total ship engineering and operational concept (or several alternate concepts). Development alternate total ship reduced crew concepts cannot be developed in a timely fashion to support the overall schedule of this task, nor can these concepts be adequately developed within the projects resources.

The reduced crew concepts developed in this task will address alternatives at the functional or departmental level, e.g., crew concepts for bridge, engineering and auxiliaries, deck, and for special evolutions such as damage control.

Reduced crew concepts in at least ten areas will be generated. Since the survey has yet to be performed, it's difficult to designate where specific crew reductions concepts will be generated. Likely areas include:

Functional/Operational areas:

- Bridge
- Engineering
- Auxiliaries
- Stores handling
- Shore support
- Command and control
- Deck operations
- Hotel and personnel support
- Damage Control

• **Maintenance strategies**

- Philosophy
- System surveillance and diagnostics

• **Total Ship**

- Computing
- Watchstanding
- Ship surveillance and control

Concepts will be developed according to the following steps:

Step 1 Collapse (in the database) observations across functional areas (for example, all observed approaches to reductions in workload for engineering activities)

Step 2 For each functional area, identify common approaches and experiences.

Step 3 For each functional identify recurrent themes

Step 4 Identify any countermanding approaches (for example, automating a function and eliminating a function)

Step 5 Identify actual or estimated workload or crew reductions for each techniques in each functional area

Step 6 Express workload reduction technique within a functional area as a list (of workload reducing opportunities)

Step 7 Package each concept into:

- A staffing strategy (for example, in a bridge strategy, identify watch stations, rotations, types of personnel required, numbers required)
- General procedures of operations
- Applications of technology (automation) or procedures required
- Implications on training and personnel categories required

- Special cost factors that may have been identified (maintenance, shore support, implementation)

Where strategies cannot be developed in functional areas due to the information collected, but where it is believed that additional workload reduction can be realized, requirements for additional research will be specified.

2.6 Cost Analysis

The staffing and maintenance strategies identified by the Coast Guard as being viable for the Deepwater Surface Platform will be analyzed for life-cycle cost impacts. For each selected strategy, the cost analysis will consider:

a) change in number of assigned crew,

b) change in number shore support level,

c) acquisition, maintenance, and training costs of applicable automation technology,

d) maintenance cost impacts of the selected strategy, and

costs of developing and implementing the strategy

The staffing strategy survey will identify the crew reductions achieved and costs of implementing and operating the strategies. Government furnished Standard Coast Guard personnel cost data for both afloat and ashore will be used to quantify the personnel cost impact of the selected strategies. The personnel impacts (reductions and increases) will be combined with the acquisition and implementation costs of the strategies to determine the life-cycle cost impacts.

3.0 REPORTING

A final report will be prepared that documents:

- The survey procedures
- Participating organizations
- Survey results
- Crew reduction concepts
- Cost Analyses
- Requirements for additional research.

Drafts of all reports will be generated for USCG review and comment. The final report will be submitted only after complete review and acceptance of drafts.

Electronics versions of all data will be provided, including:

- Database of survey results (Filemaker Pro for Macintosh and Windows95)
- Final reports (Microsoft Word version 6.0)

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Attachment A

Overview Survey

Overview and Objectives

The overall objective of this effort is to support the development of an optimized staffing strategy for the Coast Guard's Deepwater Project (DWP). Optimized staffing is the minimum crew level for a ship consistent with human performance and safety requirements, technology availability, affordability and risk. Optimized staffing also encompasses optimized crew performance, workload, and safety. Optimized crew performance means that each crew member, acting alone or in a team, will be capable of performing all tasks as required, to the required accuracy and throughput, and within time constraints, in all expected mission conditions. Optimized workload refers to the level of sustained workload which will not lead to human errors, either through fatigue or boredom. Optimized safety means zero accidents.

The basic approach reflected in this plan is to examine already implemented workload and manpower-reducing efforts of maritime fleets (commercial and US and foreign Navies and Coast Guards), assess their success at workload and crew reduction, and identify potential approaches that may be adopted by the United States Coast Guard and the DWP. Existing crew reduction efforts are sought to be surveyed according to:

- Strategies employed to reduce workload
- Effects of those strategies on mission effectiveness and safety
- Costs of implementation
- Life-cycle costs of reduced crew platforms
- Applicability to the DWC program
- Implications of crew reduction techniques on human and system performance.

Participation Solicited

The United States Coast Guard is requesting assistance by providing information and data related to implemented, and successful, workload reducing techniques and methods. These can stem from military or commercial ships, and associated shore infrastructure required to implement reduced ship workload.

The mechanism for collecting these data is an interview, conducted either person-to-person, video conferencing, or by telephone call. Two interviews are performed. One consists of questions intended to gather ship system wide workload reducing strategies, for example, heavy use of ship wide alarms or restructuring of watchstanding organizations. The second interview examines system/function specific workload reducing technologies and strategies, for example, use of automated line tensioners for mooring or provision of automated navigation systems.

In each interview session, the following types of personnel are asked to be present, as applicable:

- Shore support or management - this includes base support personnel for military ships where shore infrastructure is effected by reduced workload efforts.
- Ship management - this includes a reduced manned ship officer.
- Working crew - Chiefs or petty officers for military vessels, or licensed mariners for commercial ships are requested to discuss function/system specific workload reducing approached.

Survey Components

The survey consists of two parts. The first is a summary that establishes an overview of the missions, operations and maintenance characteristics of the ship(s) with reduced crew. It is intended to capture the typical elements of life-at-sea aboard the ship under review and the overall workload reducing strategies employed. Specifically, this portion of the survey summarizes:

- Total ship crew
- Overall staffing/crewing philosophy
- Missions
- Environments
- Watch Standing and Duty Stations
- Staffing Philosophies and Crew sizes
- Normal and special operations and evolutions
- Support functions
- Maintenance (unit, intermediate, depot)
- Training (on board)
- Applications of automation

This portion of the survey is estimated to require about one hour to complete. The data collection form for this portion of the survey is presented in Appendix A.

The second part of the survey addresses strategies associated with reduced crewing by specific functions or systems (see Table 1). In this survey, the functions listed in the table are reviewed, and where workload associated with a function has been reduced, the specific means by which that reduction is accomplished is discussed.

Begin by getting information on those being surveyed:

Name	Rates and Certifications	Years Experience	Reduced Crew Experience

Ship Information:

LOA:
Crew size:
Displacement:
Mission Summary:

Missions				
Typical Scenario:				
Typical evolutions:				
Special Evolutions:				
Sustained operational periods:				
Per Week	Legs at sea	Port stops	Stop Duration’s	Crew In port obligations

Crewing Philosophy

Watch Standing and Duty Stations:
Watch Stations:
Watch rotations:
Variability (readiness conditions, short crews, special crews):

Crewing:
Officers
Non-commissioned
Enlisted
Crew continuity
Working riders (counted as part of crew?)
"All Hands" evolutions

Environment
Seas sailed:
Weather conditions encountered:
Stand downs:

Crew Support
Berthing
Laundry
Food service
Recreation
Family
Safety

Fatigue Monitoring and Control
Are attempts made to monitor crew fatigue? If so, what are the tools and mechanisms used?
Is there a Crew reporting system in place related to fatigue?
Are mechanisms in place to control fatigue?

Operations
Workday
Workweek
Stand-down periods
Ship-Shore collaboration
Internal communications
Deck
Command
Engineering

Applications of Automation

Procedural/Doctrinal approaches to reduce workload

Cost Factors
Identify cost factors associated with reducing workload and manpower. Please Identify costs associated for each approach used to reduce workload, including: • automation technology • changes in procedures • changed in philosophy • modifications to ship and shore infrastructure For each area above, please identify costs associated with: • Investment (e.g., R&D, acquisition and purchasing) costs • Effects on annual Operations and Maintenance costs • Equipment life expectancy • Impact on crew structure (e.g., number of crew, training costs, retention costs)

Attachment B

Functional Survey

In this survey, following the Overview survey, we are interested in identifying function or system specific efforts to reduce workload. This survey is performed in two parts: (1) specific functions/systems where work has been reduced, and (2) for each function or system, identifying the specific work reducing approach taken.

Step 1. Identifying specific functions. From the table below, review the functions and identify any specific functions or related systems where workload has been reduced. Place a check or other mark by each appropriate function.

Mission Operations	**Special Operations**
Boat Handling/Boarding	Underway Replenishment
Area Surveillance	Electrical Failure
Communications - Internal	Extreme Weather
Communications - External	Fire - Large and Small
Weapon and /Combat Information	Flooding/Ballast control
Helicopter/UAVs	Collision/ Grounding/ Stranding
NOAA/Weather services	Internal Security
Oceanographic	Loss of Propulsion
SAR	Search and Rescue
Deck Operations	Boarding/Law Enforcement
Anchoring	Anti-Terrorism
Docking Undocking	Man Overboard/Rafters
Helo Operations	Fuel Spills/Environment Hazards
Boat operations	Lifeboat
Line Handling/Mooring	**General Operations**
Anchor	Bridge - Housekeeping
Towing Operations	Bunkering
Underwater Lighting	Deck Equip Maintenance
Navigation/Bridge	Direct Shore Gangs
Approach Berth	Docking/Undocking
Berthing	Line/wire Maintenance
Collision Avoidance	Medical
Depart Berth	Stores Breakdown
Hull Performance/Station Keeping	Steering Gear Maintenance
Maintenance	Stores Handling/Breakdown
Maneuver	Structure Maintenance

Lookouts	Wash down - Deck
Signals	Wash down - Engine
Position Fixing	**Administration**
Record/chart Keeping	Reporting
Track Keeping	Health Care
Voyage Planning	LAN Maintenance
Weather Monitoring	Finance/Payroll
Hotel/Unit Support	Ships Meetings
Catering/Messing	Mission Planning
Laundry	**Shore Operations**
Provisioning	Stores loading
Space Cleaning	Port Logs/Records
Waste Disposal	**Maintenance - Ship area**
Maintenance - Overview	Vital Systems Test
Maintenance Philosophy	Equipment Surveillance
Depot/Shoreside	Computers
Intermediate	Electric System
Hull	Evaporators
Unit	Fuel Oil
Training and Personnel Support	Fuel Transfer
Off ship and Schools	Generators
OJT	Inert Gas
Cross training	Propulsion
Engine and Auxiliaries Operations	Pumps/Valves
Record Keeping	Tools/Test Equipment
Routine Operations	Communications
Watch Standing	Boat Maintenance
	HVAC
	Housekeeping (common and rec areas)

Step 2. Complete (as appropriate) the following survey for each functional area identified above.

Mission Operations	**Considering this grouping of functions, collectively or individually, address the following items.** **Frame your answers, if possible, by comparing to experience with a baseline level of workload or crew size.** **Hard data (or estimates) expressed as hours, dollars, MTBFs, etc. are preferred over soft estimates.**
Boat Handling/Boarding	
Area Surveillance	
Communications - Internal	
Communications - External	
Weapon and /Combat Information	
Helicopter	
NOAH/Weather services	
Oceanographic	
SAR	

Workload Reduction/Crew Reduction Observed
How was crew/workload reduction achieved for this function?
How much workload (expressed in personnel hours per week) or how many crew members were reduced by this approach?
Application of automation: Vendors/suppliers:
Redesign of operating procedures or Philosophy
Other or concurrent approach?:

What were the cost implications for this workload/crew reduction?
R&D:
Acquisition and implementation:
Logistics and life cycle support:
Decommissioning:
Personnel (by rating, paygrade, series):
Are there any observed or suspected risk factors?

Have any performance implications been observed for this functional workload/crew reduction? If so, how are they being addressed?
Operational changes:
Shore infrastructure:
Readiness:
Reliability/availability:
Maintainability:
Safety:
Personnel Readiness:
Personnel Fatigue:
Training:

Is there an approach or technology under development to reduce crew workload related to this function?

Are there any knowledge gaps related to this function or activity such that research is required?

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DEEPWATER CREWING PROJECT. **Foreign/Commercial Ship Crewing** from Jane's Fighting Ships 1997-98

Country	Type	Class	Reduce d	Crew	Personnel	Length	Displace-ment	Compl./ Length	Compl./ Displ.
			Crew	O+E		(ft.)	(tons)		
Denmark CG	Frigate	Niels Juel		94	?	275	1320	0.34	0.07
		Thetis	**	60		369	3500	0.16	0.02
		Hvidbjornen	*	56		245	1970	0.23	0.03
	Patrol	Willemoes	*	25		151	260	0.17	0.10
		Flyvefisken	*	29		177	480	0.16	0.06
		"O"		19		84	155	0.23	0.12
USCG	WHEC	Hamilton		167	military	378	3050	0.44	0.05
	WMEC	Reliance		75	"	210	1130	0.36	0.07
		Famous		100	"	270	1825	0.37	0.05
US Navy	DD	Burke IIA		380	military	509	9217	0.75	0.04
		Burke I&II		303	"	504	8422	0.60	0.04
		Kidd		363	"	563	6950	0.64	0.05
		Spruance		339	"	563	8040	0.60	0.04
	FF	Perry		206	"	445	4100	0.46	0.05
	MCM	Avenger		81	"	224	1312	0.36	0.06
	MHC	Osprey		51	"	188	918	0.27	0.06
	PCF	Cyclone		28	"	170	334	0.16	0.08

Country	Type	Class	Reduced	Crew	Personnel	Length	Displace-ment	Compl./ Length	Compl./ Displ.
Japan MSA	PLH	Shikishima	*	110	?	492	9350	0.22	0.01
		Mizuho	*	100		426	5204	0.23	0.02
		Soya	*	71		323	3744	0.22	0.02
	PL	Shiretoko	**	41		255	1360	0.16	0.03
		Ojika	**	38		300	1883	0.13	0.02
Japan MSDF	DD	Yamagumo		220	military	377	2150	0.58	0.10
	DDG	Kongou		307	"	528	7250	0.58	0.04
	DD	Murasame		166	"	495	4400	0.34	0.04
	DE	Abukuma		120	"	357	2550	0.34	0.05
Sweden CG	KBV	181	**	11	?	184	800	0.06	0.01
		171	**	8		164	375	0.05	0.02
Norway CG	OPV	Nordkapp	*	52	?	346	3240	0.15	0.02
Canada CG	500	Reid	**	14	civilian	164	836	0.09	0.02
	600	Grenfell	**	20		224	3753	0.09	0.01
	FPV	Cowley	**	19		236	2080	0.08	0.01
France FSMC	PC	P 400	*	26	military	178	477	0.15	0.05
	PG		**	46	"	278	2800	0.17	0.02

Country	Type	Class	Reduced	Crew	Personnel	Length	Displace-ment	Compl./ Length	Compl./ Displ.
France Navy	DDG	Horizon	*	200	military	486	6500	0.41	0.03
	FFG	La Fayette		139	"	407	3600	0.34	0.04
	FFG	Floreal	*	86	"	307	2600	0.28	0.03
Ireland	OPV	Eithne		73		265	1760	0.28	0.04
	OPV	Deirdre		47		184	972	0.26	0.05
UK Navy	FFG	Duke		174	military	436	4200	0.40	0.04
	MHC	Sandown	*	34	"	172	484	0.20	0.07
Germany Navy	FFG	Brandenburg		199	military	456	4700	0.44	0.04
	FFG	Sachsen		230		469	5600	0.49	0.04
Germany CG	PC	Bredstedt	**	18	?	214	673	0.08	0.03
	PC	Sassnitz		33		160	369	0.21	0.09
			* -- small length <u>or</u> displacement ratio						
			** -- small length <u>and</u> displacement ratio						

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APPENDIX C

Literature Search Findings Data Base

Appendix C - Literature Search Results

Matthew A. Green. The Future of Minimal Manning and Its Effects on the Acquisition and Life-Cycle Costs of Major Coast Guard Cutters. (January 1999)

Abstract: Since the 1970's, the world's merchant fleets have been pursuing crew reductions as a way to cut costs: however, the United States military has been slow to adopt this trend. In the current age of tight budgets and defense cutbacks, the Coast Guard and Navy can no longer afford to continue in this manner Both services have now initiated research and acquisition projects which address minimal manning. These projects must be carried out and minimal manning practices implemented if our sea going services are expected to maintain their edge as world leaders. This paper presents a study designed to research the quest for minimally manned crews and its applicability to military vessels. It is meant to provide guidance to the United States Coast Guard and other interested parties on future surface combatant acquisition projects including but not limited to the Coast Guard Deepwater Program. Emphasis is placed on the theory behind automation and the organizational impacts associated with minimal manning.

http://www.dt.navy.mil/smartship/smartship.html. US Navy Smart Ship Home Page. (1999)

In October 1995, the Naval Research Advisory Committee (NRAC) briefed reduced manning concepts applicable on U.S. Navy ships. Based on the NRAC findings, the Commander, Naval Sea Systems Command and the Commanding Officer, NSWC Carderock, stood up a team of volunteers in November 1995 to research labor and manpower saving ideas. This Project, title Smart Ship, was endorsed by the CNO in February 1996. From the outset, the Smart Ship Project has used the USS YORKTOWN (CG 48) as the platform for demonstrating innovative technology aimed at reducing manning requirements and life cycle costs. The Smart Ship Project currently has 61 initiatives on board YORKTOWN, within the categories of Combat Systems, Hull Mechanical & Electrical, Own Unit Support and Manpower Personnel Training & Assessment. These initiatives continue to support the Smart Ship Charter - reduction of manning and related cost savings on present and future U.S. Navy Surface Ships. The methodology that has been developed by the Smart Ship Project for reviewing, testing, evaluating and reporting new ideas will continue in the outyears. The Project has also begun to leverage the success of YORKTOWN onto other AEGIS Cruisers through the Integrated Ship Controls (ISC) Program. It is clear that reduced manning is an essential element, if not the essential element, in affording the Navy of the future.

http://www.strath.ac.uk/Departments/ShipMarine/masis.htm. Human Element in Man/Machine Interface and Interaction to Improve Safety and Effectiveness Transport for the European Fleet. (1999)

Project Summary: MASIS II is a European Commission sponsored project under DGVII of the commission. Human Element in Man/Machine Interface and Interaction to Improve Safety and Effectiveness Transport for the European Fleet It consists of five Work packages:

Workpackage 1: Human Behaviour in Emergency Situations and when Operating with Multi-cultural and Small Crews

Workpackage 2: Socio-Economic Impact of the Development of New Shipboard Management Concepts†

Workpackage 3: New Management Structures based on ISM Code for Ship owners and Ship Operators

Workpackage 4: Workplace Design Requirements Under Ergonomic Aspects

Workpackage 5: Performance Standards for Shipboard Hand Book on "Small" Crews In Emergency Situations

The use of reduced numbers of crews aboard ship has been the trend over the past decades in shipping World-wide. In the past ships may have operated with 60-100 crew members, while now a similar vessel may be operated by only 10-30. The reasons for this trend are relatively simple and are mainly economically driven.

Alden M. Hayashi. Scientific American: Technology and Business: Rough Sailing for Smart Ships (web-site). ROUGH SAILING FOR SMART SHIPS. Does commercial software such as Windows NT compromise naval ship performance?. (November 1998)

Three years ago the U.S. Navy commenced a bold plan for slashing costs while preparing its fleet for the next century. The program, dubbed "Smart Ship," called for a reduction in crew levels through increasingly computerized ships. Additional savings would be achieved by using commercial off-the-shelf products, such as Pentium-chip computers, instead of expensive custom parts to build the now automated systems. But Smart Ship has recently encountered rough waters. A major computer crash on board the first of the automated ships has led to harsh criticisms of the navy initiative, and the dispute has touched off ugly accusations that important technical decisions are being controlled by politics-not by engineering.

Appendix C - Literature Search Results

David W. Aha and Leonard A. Breslow. Comparing Simplification Procedures for Decision Trees on an Economics Classification. Navy Center for Applied Research in Artificial Intelligence Information Technology Division. (May 1998)

Abstract: Several commercial case-based reasoning (CBR) shells now use decision trees to index cases, including ReMind (Cognitive Systems, Inc.), Kate (AcknoSoft), and The Easy Reasoner (The Haley Enterprise). These trees serve to expedite case retrieval and to generate comprehensible explanations of case retrieval behavior. Unfortunately, induced trees are often large and complex, reducing their explanatory power. To combat this problem, some commercial systems contain an option for simplifying decision trees. However, while many methods for simplifying decision trees exist, they have not been systematically compared and most have not been applied to case retrieval. This report builds on our previous survey and initial empirical comparison of tree simplification procedures. In this report, we compare them on a specific, challenging task that is the focus of an existing CBR effort. We examine which tree simplification procedures are useful for this task and suggest which ones should be included in a commercial CBR tool.

A. Anderson, A. Macander, M. Mulhern, R, Walls, A. Matulich, ABHC(SW) T. Quillen, S. Torfin. DeckOps 2020 - A Vision for Future Deck Operations. (January 1998)

Present-day weather deck equipment often requires intensive manpower for operation and maintenance, which conflicts with reduced-manning requirements on future ships. In addition, present systems increase radar cross section (RCS) "clutter." The shape, orientation, and surface area of ship hull structures and exterior equipment will require changes to control radar, acoustic, and infrared signatures. Furthermore, total ownership cost must be reduced. The DeckOps 2020 Innovation Team examined the anticipated future ship requirements, and developed a number of innovative concepts to accomplish the necessary deck operations. The team developed a process to identify shortcomings as well as alternative solutions for specific operational components. Several solutions were integrated to form the concept of Zero Manning On Deck (Z-MOD); essentially a philosophy for submarines applied to surface combatants. Eliminating the need for personnel topside significantly decreases manning requirements, weather deck maintenance, and radar cross section clutter. The DeckOps 2020 team laid the foundation for the future of deck operations in a world of low manning and low signatures while maintaining affordability. This report documents the systems engineering process as well as alternative solutions to deck operation problems.

US Coast Guard Engineering Logistics Center, Naval Architecture Branch for Deepwater Surface Matrix Project Team. Comparative Practices of European Frigates and Offshore Patrol Vessels. (January 1998)

The Deepwater Project Surface Matrix Product Team met with shipbuilding industry executives and Naval and Coast Guard leaders of Italy, Denmark, The Netherlands, France, England, Norway, Germany and Sweden to investigate seventeen multi-purpose frigates and offshore patrol vessels.

The objectives of this trip were to identify and compare design and operational practices and technologies which would assist the U.S. Coast Guard in performing their missions more effectively in the Deepwater environment. In addition methods for reducing life cycle cost through the use of current, non-developmental technologies were sought.

During the meetings the discussions focused on Mission Profiles of the Vessels, Crewing of the Vessels, Habitability, Maintenance Issues, Propulsion Systems, Design Criteria, Boat Launch and Recovery Systems, Aircraft Launch and Recovery Systems, and Damage Control Technology.

American Bureau of Shipping. Guidance Notes on the Application of Ergonomics to Marine Systems. (January 1998)

The study of the human element and its impact on industrial safety has greatly expanded in recent years. It has moved from just the study of human factors to considering management, organizational and social factors. The applications of this body of knowledge, however, has not been as widely applied as the volume of literature would suggest.

Its application in the marine industry is particularly scarce. Fortunately, the importance of the human element in maritime safety has been recognized by the shipping community and has received more attention due to the efforts of the International Maritime Organization (IMO). These Guidance Notes are prepared as a step in fostering the application and understanding of this knowledge.

Appendix C - Literature Search Results

William Nickerson. 501-K34 Maintenance and Diagnostic Requirements WORKSHOP Meeting Minutes. (February 1998)

Executive Summary: This document describes the results of a workshop to identify maintenance and diagnostic opportunities in the Allison 501 -K34 Ships Service Gas Turbine Generator (AGT-9140). This workshop was targeted at determining the location, type and hierarchical structure of health monitoring technology being developed under a Future Naval Capabilities Option (FNCO) for Machinery Diagnostics and Prognostics under sponsorship of the Office of Naval Research. The approach of the workshop was consistent with, but not a direct application of, the Reliability-Centered Maintenance (RCM) process. RCM was developed for the purpose of defining a preventive maintenance philosophy. Our intent is to investigate the application of condition-based maintenance (CBM) to a complex mechanical system. While many of the concepts and tools of RCM apply and should be used, the "weighting factors" at decision points and some of the considerations should be different. Certainly the technology available for monitoring and diagnostics of mechanical systems is dramatically different than that available when RCM was developed. One of our intents was to evaluate an alternative, "CBM-centric" application of RCM principles in an effort to establish new tools and techniques for an updated look at the process of establishing "applicable and effective" maintenance practices in the context of available and developmental diagnostic technology. The workshop brought together experts from all aspects of the life cycle of the application equipment, AGT-9140. The attendees included the Original Equipment Manufacturer, In-Service Engineering Agent, Life-Cycle Manager, Direct Fleet Support Activities, and end users from the USS THE SULLIVANS. The combined experience of these experts interacting with the technology developers provided an interesting discussion of the real problems experienced with the AGT-9140 during it's life cycle and allows the development community to address specific issues. The attendees are listed with contact information in Table 1, the meeting is summarized, and presentations made by the FNCO team are included as appendices. Experienced problems, rationale for attention to them and potential approaches discussed during the workshop are listed according to subsystem in Table 2, Table 3, and Table 4. The FNCO developers are using this information to refine specific technology developments for the current project.

Bost, R.J. et al.. Human-Centered Automation in Total Ship Engineering. (1998)

To achieve required reductions in life cycle costs, combatant ships acquired in the future will be manned at significantly reduced levels as compared with existing ships. The major engineering method for achieving shipboard manpower reductions is to increase the level of automation in the control of ship system and total ship functions. A major engineering challenge to this approach is to effectively integrate human performance with automation. Lessons learned from a wide variety of complex system developments indicate that increasing the level of automation without adequately considering the roles and requirements of humans in the system results in higher human error rates, greater potential for accidents, extended personnel training pipelines, and degraded system performance effectiveness to the extent that human performance contributes to system performance.

Ship manpower reduction concepts are being developed through the application of human systems integration (HSI). An element of HSI concerned with the design of human machine interfaces to support the performance of humans in highly automated systems is designated Human-Centered Automation (HCA). This initiative has been in use by the FAA and NASA in their concern for pilot performance on the flight deck of highly automated commercial passenger aircraft. Essentially, HCA is an extension of HSI applied to automated systems. HCA is the systems engineering approach to automation focused on the roles and requirements of humans interacting, cooperating, coordinating, and collaborating with automated processes. HCA is concerned not only with human requirements in automated processes, but also with requirements for automation to support human performance, such as with decision support systems and operator's associates. The approach to addressing HCA in system design and development requires a 7 step process: (1) allocating functions to identify which system functions should be performed by humans or should require interaction between human and automation; (2) identifying human and machine roles for system functions; (3) conducting task analyses to identify task sequences and requirements to support assigned roles; (4) developing design concepts for ensuring effective interaction and coordination between human performance and automation; (5) identifying technologies needed to support design concepts; (6) assessing design concepts through modeling and simulation; and (7) defining human-machine interface design and evaluation requirements. This paper will discuss the HCA process and how its application will result in safe and effective ship manning reduction, workload reduction, and human error reduction.

Malone, T.B., Anderson, D.E., Williams, C.D., and Baker, C.C.. REQUIREMENTS TO ENSURE CREW SAFETY IN REDUCED MANNING SHIPS. (1998)

In the interest of reducing the life cycle costs associated with operating Navy ships of the future, and even some ships of the present, emphasis is being placed on reducing the manpower complement of these ships, thereby significantly reducing operational and support costs. The SC 21 and CVX are being designed for major reductions in required manning as compared with the baseline ships. Future Fast Sealift ships are also being designed to operate with significantly smaller crews. The Smart Ship Program is demonstrating how manning on existing ships can be reduced through applications of technology, and changes in culture, tradition, policies, and procedures.

A major concern with ship manpower reduction is the potential deleterious effect that these reductions may have on crew safety. The major concern for safety in a reduced manning ship is the adverse impact that reductions may have on workloads of remaining crew. Increased workloads lead to fatigue, impaired judgment, reduced decision making time, and stress, all of which have a negative impact on human performance, and ultimately, on human safety.

Reduced manning ships will be made safer through a design approach that strives to reduce the workloads imposed on remaining crew. This approach consists of three major steps: 1) implementation of a systems engineering top-down analysis of system functions, to achieve an understanding of the requirements associated with performance of functions by the ship/system; 2) development of alternative design concepts based on function automation, consolidation, simplification, and elimination; and 3) modeling of human performance, measurement of human workloads, and assessment of the potential for human error and fatigue in simulations of systems operations under selected scenarios for alternative design concepts.

Malone, T.B., Anderson, D.E., and Baker, C.C.. RECAPITALIZING THE NAVY THROUGH OPTIMIZED MANNING AND IMPROVED RELIABILITY. (1998)

Reduced manning is the process and the result of removing human functions from a system while retaining or improving system operability and effectiveness. Reliability and maintainability characterize a system's operability and effectiveness. Reduced manning impacts system reliability by changing the characteristics of (1) human error associated with system operation and maintenance, (2) time to repair failed components, and (3) mean-time-between-failures (MBTF) in a reduced manning environment.

Simply reducing manning without compensating for system dependence on human involvement generally has a negative impact on system maintainability. Methods to address this include (1) human-system integration design of maintenance interfaces and (2) design of operations activities that are closely related to device failures. Examples of design approaches that benefit system maintainability are: reducing the need for maintenance through use of highly reliable equipment, employing device redundancy, providing automated test and diagnostics, and designing to enhance human reliability by providing decision support tools which assist in making diagnostic decisions while reducing skill requirements and training burden. Combined design and operational actions to enhance system maintainability include: improving maintenance accessibility, improving usability and readability of maintenance procedures, and providing workplace conditions which enhance maintainer safety and health. Operational methods that enhance maintainability are: reducing maintainer workload and increasing productivity, and reducing the time to repair. After demonstrating reliable performance through testing and operation, ship commanders can be assured that fewer people can effectively operate and maintain Navy ships and systems.

Malone et al. Payoffs and Challenges of Human Systems Integration (HSI) Modeling and Simulations in a Virtual Environment. (1998)

To ensure that the human component is adequately addressed in system de-sign, requirements for human performance, manning levels, training, and safety, the elements of human systems integration (HSI) must be considered early in the design process. HSI requirements are integrated through implementation of HSI modeling and simulation (M&S). Objectives of HSI M&S are to: (1) assess alternative concepts in terms of human performance, productivity, workload, and; (2) provide human performance in-puts to system level simulation, and determine the impact of system design and organization on human performance and safety; (3) quantify relationships between human capabilities and system characteristics; and (4) visualize and quantify spatial relationships between humans and system elements. Payoffs of HSI M&S are the ability to: (1) acquire data on human performance, skills, and safety provisions in advance of system construction; (2) model human performance in system concept alternatives; (3) assess human performance as a function of human machine interface (HMI) design concepts; and (4) assess team performance as a function of HMI design, communications design, and collaborative problem solving. Challenges of HSI M&S in a virtual environment include problems associated with: (1) virtual interfaces (of the simulated system); (2) human perception and cognition in virtual environments; (3) virtual object manipulation; and (4) quality of data acquired during simulation.

USCG. Marine Safety Manual. Volume III Marine Personnel. 1998. Chapter's 20 to 24 Manning Requirements. United States Coast Guard. (1998). Dept. of the Navy. Smart Ship Project. USS Yorktown (CG-48). "Smart Ship" Assessment Report. (September 1997)

OBJECTIVE: Our objective was to identify, document, and report all costs relating to Smart Ship innovations installed and implemented onboard the USS YORKTOWN (CG-48).

BACKGROUND: The Chief of Naval Operations (CNO) established the Smart Ship Project in December 1995. The project's objective was to evaluate and select solutions that demonstrate potential reductions in a crew's workload that can be achieved on an operational surface combatant. The USS YORKTOWN was selected as the prototype platform. The primary goal of the Smart Ship Project was to accomplish the ship's mission with a smaller crew, thereby reducing costs. The goals also include improving mission readiness and maintaining safety. innovations were installed and implemented onboard the USS YORKTOWN through December 1996, when the ship began a 5-month deployment during which achievement of project goals would be assessed. Assessment is to include a determination that the ship meets its required operational capabilities and that the concept can be sustained. Assessment will also include a cost-benefit or return-on-investment analysis.

In August 1996, the Commander, Naval Sea Systems Command (COMNAVSEA) invited the Auditor General of the Navy to participate on the project. As part of an innovative teaming arrangement, Naval Audit Service provided advisory/consulting services to management on assessment planning, and a review of pre-deployment integrated logistics support. COMNAVSEA requested that the Naval Audit Service assist the team in collecting cost data needed for the cost-benefit analysis portion of the assessment. In January 1997, COMNAVSEA and the Auditor General of the Navy agreed the cost collection effort would comply with generally accepted government auditing standards (to the extent practical), but would not be an audit. COMNAVSEA and Commander, Naval Surface Force, U.S. Atlantic Fleet (COMNAVSURFLANT) would assume responsibility for access to information. The results of the effort would be part of the Smart Ship assessment report due to CNO by the end of June 1997.

Davis, S.C., Hamilton, K., Heslegrave, R.J., and Cameron, B.J. Ergonomics and Human Factors Group-BC Research Inc. Study on Extended Coast Guard Crewing Periods. (February 1997)

EXECUTIVE SUMMARY: To enhance the efficiency and productivity of its operations, the Department of Fisheries and Oceans/Canadian Coast Guard (DFO/CCG) wished to investigate whether crewing periods could be extended from 28 to 42 days without compromising crew and vessel safety. To examine the level of risk to crew and vessel safety, crew state was examined during 28- and 42-day periods aboard the icebreakers Sir Wilfrid Laurier and Pierre Radisson respectively. Specific human performance measures for bridge and engineering watch-keepers included measures of cognitive performance, sleep, fatigue, and socio-psychological well-being. In addition to the central question concerning extended crewing periods, a number of other issues were explored to determine whether various aspects of CCG operations might promote or inhibit the onset of performance impairment. Factors included: watch type; the impact of prolonged versus shorter icebreaking operations; the relative time (early or late) of icebreaking operations within the patrol; the influence of workload; and the physiological adaptation of persons to different watch schedules. These issues are potentially significant modifiers of fatigue effects. As part of the study, a task analysis was conducted on bridge and engineering watchkeepers to identify the types of tasks and modes of operation (e.g., icebreaking, SAR (Search and Rescue)) in which fatigue effects are of the greatest potential concern. Using Fleet Activity Information System (FAIS) data, levels of vessel workload were compared to determine if the workload observed during the data collection period in 1996 was representative of that for the previous year. The results of the investigation can be summarized as follows:

> Signs of apparent deterioration in crew state began to emerge when the crewing periods were extended from 28 to 42 days. These included: perceptions by the crew that their performance was starting to degrade; increased frustration, withdrawal, irritability, and apathy; and some indication of reduced sleep, particularly after week 4.

Compared to the 4&8, crew state appeared moderately better on the 12&12 watch, based on the measures of sleep, fatigue, mood, and group dynamics and morale. Although personnel on the 12&12 watch schedule reported higher workloads, they were more satisfied with their performance, more cheerful, and recorded better group dynamics and morale.. The personnel on the 4&8 ship reported greater frustration, degraded task and mental performance, more withdrawal, and greater irritability.

RECOMMENDATIONS: Based on the results of this study, the following recommendations are provided:

-Extended crewing periods should be implemented in an organized manner including continued evaluation of the effects of extended crewing on human performance.

-Introduction of a 12&12 watch schedule should be considered for Arctic icebreaking operations because it offers a better opportunity for improved watch management through modifications to procedures during relatively low workload periods. The 12&12 watch schedule also provides the opportunity for a longer, uninterrupted period to sleep.

-Crewing requirements should be matched to anticipated workload so that the crew can achieve maximal sleep and rest.

-Crew should be provided with opportunities for strategic rest periods or to take naps so that they can achieve maximal sleep and rest.

-Opportunities for crew to rest should be provided during periods of extended icebreaking.

-If icebreaking is late in the duty cycle, additional rest and extra precaution are required.

-Crew preference must be considered before implementing a 12&12 schedule, particularly if it is in a region unfamiliar with this type of watch.

-If 12&12 watches are implemented, vigilance testing is recommended to assess the impact on human performance.

-During weeks 5 and 6 of an extended crewing period, tasks identified by the task analysis as sensitive to fatigue should be minimized wherever possible.

-Tasks identified as sensitive to fatigue by the task analysis should be minimized at night until further circadian rhythm data are collected.

-A training program should be implemented to provide crew with information about coping strategies that will help them deal effectively with extended crewing periods.

-Older crew members should be assigned to day watches, as aging affects an individual's ability to adapt to changes in their sleep pattern.

-Sufficient time off needs to be provided between successive 42-day cycles, to ensure that crew can recover adequately.

US Coast Guard HQ, Naval Engineering Division G-ENE-5a. WAGB-20 Polar Icebreaker Crewing Study Update. (April 1997)

EXECUTIVE SUMMARY: This report, as an update of the Crewing Study for Polar Icebreaker Replacement Cutter, of 10 November 1992 (re-issued 24 January 1994) and the WAGB 20 Polar Icebreaker Shore Support Impact Analysis Continuation of I June 1995, analyzes the workload and manpower impacts based on a clearer definition of the ship design, and changes in the projected operating schedule, the crew rating mix and the equipment to be installed. This effort consisted of a re-development of the preventive maintenance (PM) workload, facilities maintenance (FM) workload, operational manning (OM) and evolutions, as well as improvements in the manning models.

Based on Project Office guidance, the annual deployment schedule was changed from our previous studies from 147 days deployed and 217 days in home port to 200 days deployed and 165 days in home port., It was assumed that the time spent in foreign port would remain at 35 days, with 165 days at-sea, since this would maximize the time available for science operations at sea. The increased time at-sea results in the accomplishment of more workload, and thus a reduced deployed backlog. The reduced amount of time in home port results in a reduced home port backlog, but has the effect of increasing the number of shore support (ISF) billets due to the reduced time in home port to accomplish the backlog. Additionally, since the WAGB 20 Polar Icebreaker Shore Support Impact Analysis Continuation was submitted, 2 ship's crew billets have been added, increasing the number of enlisted personnel from 55 to 57. The addition of these two billets results in a decrease of 4,780 man-hours of workload backlog.

The Preventive Maintenance (PM) database was re-develoved in order to ensure all of the equipment (with PM requirements) going on board the Healy and the associated maintenance actions were identified. The PM was compared with the latest available Material Ordering Schedule (MOS), the Master Electronics Equipment List (MEEL) and the Functional Configuration Baseline Index (FCBI) to determine what equipment should be added (this was an ongoing process, and as the equipment lists were further refined, so was our PM database). Wherever possible, the older preventive maintenance requirements were updated with the latest Maintenance Procedure Cards (MPCs) (for 400' WAGB, dated 3/93 - 3/96). As a follow up to the MPC update, MPCs from the new Electronics PM Manual for the Healy were used wherever available (this manual, however, was only partially complete). PM requirements for the remaining equipment were developed primarily from Navy MIPs, and in a few cases, analyst estimate. Through the course of the PM database development, 1,094 maintenance actions/ equipment records were added and 276 were deleted. The net impact of this analysis was a reduction of 26 man-hours/week in PM. More significantly, the high frequency (quarterly and more frequent) PM decreased by 82 man-hours/week, while the low frequency (semi-annual and less frequent) PM, initially planned to be accomplished only in the home port, increased by 56 man-hours/week.

The change in PM has the effect of shifting workload from the deployed period to the home port period. This shift, combined with the longer at-sea period and increase in 2 billets (despite some slight increases in watch and evolution requirements and in FM), virtually eliminates the deployed backlog and the need for a mobile maintenance team.

The Facilities Maintenance (FM) requirements were updated using the AVONDALE Contract Design Drawings (SK-16-02, Rev C). The 1992/94 WAGB 20

Crewing Study FM estimates were based on down-sizing factors taken from the crewing study for the 19-86 PIR Preliminary Design, since there were no drawings available for the various alternatives under consideration in 1992/93. This factoring process produced a deck area of 152,829 sq. ft for the 400 ft selected design alternative vs 196,148 sq. ft in the Preliminary Design. Actual measurement of all the spaces in the 420 ft WAGB 20 drawings show the ship to have neatly the same total deck area (193,572 sq. ft) as the Preliminary Design, thus, the revised FM reflects a significant increase over that estimated in the 1992/94 Crewing Study. Applying the assumption used in this study, that only habitability spaces are to be maintained fully and other spaces will be maintained at a 25% level, limited the FM impact to an increase of only 0.7 of a billet during deployment. The impact goes up to 2.2 billets during the home port period, when all spaces are fully maintained.

Watch and evolutions requirements were revised to satisfy the station requirements as specified in the Watch Quarter and Station Bill contained in the July 1996 Preliminary Cutter Training Plan for WAGB 20 Polar Icebreaker. The evolutions of Special Sea and Mooring Detail, Flight Quarters, and Science Operations were set out in databases in order to assess the manning impact of the changes and refine the minimum watch and evolution station requirements, consistent with the minimum manned crew concept. The results of these changes were an increase of 168 man-hours/week in watch requirements while in foreign port, and an increase of 74 man-hours/week in evolutions requirements while at-sea. We modeled the effects of these changes and determined that the number of crew billets are sufficient to accommodate these changes.

Maiming model runs were made showing each of the workload changes, incrementally. The manning models (at-sea, foreign port and home port) were redesigned, as newer software technology has allowed, to establish direct links to each of the workload databases. In this way, the manpower impact of each change can be assessed, as well as the overall impact. Workload cross-utilization adjustments were then

made in order to optimize the crew rating mix within the minimum manned crew concept and to update the planned shore support requirements. The overall impact on shore support requirements, without application of any contracting-out measures, is estimated to be a net increase of 7 uniformed-personnel billets, over the 75 billets estimated in the WAGB 20 Polar Icebreaker Shore Support Impact Analysis Continuation of I June 1995.

Carlow International Incorporated. Advanced Manning/Human Systems Integration (HSI) for Sealift Ship Technology Development Program (SSTDP). (1997)

EXECUTIVE SUMMARY: This report documents results and products of the Advanced Manning/Human Systems Integration (HSI) effort for the Sealift Ship Technology Development Program (SSTDP) - Future Technology Variant (FTV). The report was generated to (1) document the baseline level of SSTDP manning that is the result, in part, of ongoing workload simulation studies, and (2) describe final products and results of the advanced manning/HSI effort.

Malone, T.B., and Baker, C.C., and Anderson, D.E.. Application of Decision Support Systems for Reduced Workload, Manning and Human Error.(1997)

Two major requirements in the acquisition of modern military systems are the need to reduce life cycle costs and the demand to improve the safety of systems personnel. The major contributor to life cycle costs is the cost associated with system manpower and manpower support. Navy sources estimate manpower costs at 40 to 60% of total life cycle costs. The major factor in reduction of accidents and enhancement of systems safety is the reduction of human error potential. The U.S. Navy, Coast Guard and the International Maritime Organization have independently estimated human error to be the causal factor in 80% of on-duty maritime system accidents. In the acquisition of new ships, the Navy is emphasizing early application of human systems integration (HSI) technology to reduce both manpower requirements and human error potential. The most effective HSI technology to meet this objective is the family of software systems designated decision support systems. This paper reviews the issues and requirements associated with developing and implementing decision support systems in a military system acquisition program. The major conclusion of this paper is that only through a human-centered design approach employing HSI principles, methods and data can roles and requirements of humans vs. automation be established, and can the potential for decision support systems to facilitate achievement of the human roles be realized.

J.K. Pollard, E.D. Sussman, M.Stearns . Shipboard Crew FatigueSub-Title:Safety and Reduced Manning. (1997)

Abstract: This report describes an exploratory first phase of an investigation of human stress and fatigue in the merchant marine. Its principal purposes were to: survey the effects of fatigue on human performance in the transportation industries; describe the state of the art in measuring fatigue; investigate the causes of stress and fatigue on merchant ships; summarize the insights gained about the implications of reduced manning as well as measures to mitigate fatigue; and discuss the results of preliminary attempts to gauge fatigue during the routing voyages using survey methods. The findings in this report are based primarily upon about three dozen extended interviews conducted with officers on five merchant vessels during brief coastal voyages. In the course of these interviews, more than a score of variables were identified which affect fatigue and stress, which may be grouped into organizational factors, voyage and scheduling factors, ship-design factors, and physical/environmental factors. These interact in complex fashion resulting in widely different levels of fatigue on different ships and in different situations. The physiological and behavioral methods of fatigue measurement reviewed were found to be difficult to apply during routine operations, but the self-reporting survey techniques factors could provide opportunities under some circumstances for the design and operation of advanced merchant ships which can be sailed safely and efficiently by well-rested crews which are smaller than are common today

Williams, EC; Helmick, JS. WORK SCHEDULING AND WORKLOAD DISTRIBUTION IN MERCHANT VESSEL OPERATIONS: AN EXAMINATION OF ALTERNATIVE WATCH SYSTEMS. (1997)

ABSTRACT: Federal law generally requires that the crew of an American merchant vessel be organized into three watches. The authors review recent trends in vessel manning and suggest that, as a result of these trends, the three-watch system may now be sub-optimal in terms of maritime safety. Alternative watch systems are described, and necessary changes to Federal law are discussed.

John D. Lee [et al.]. Validation and sensitivity analysis of a crew size evaluation method. (1997). Subjects: Ships-Manning-Data processing-Merchant marine-Task analysis-Data processing. U.S. Dept. of Transportation, United States Coast Guard, Marine Safety and Environmental Protection

Commander, Naval Surface Force, U.S. Atlantic Fleet. Smart Ship Project Assessment Report (Letter report). 1997. The Smart Ship Project has demonstrated that shipboard workload reductions are possible while maintaining combat readiness and safety with significant net positive return on your investment. Expenditures on available technology and implementation of policy and procedure changes make manpower reductions achievable. The required expenditures for such changes are offset by large potential savings in manpower, both shipboard and ashore, and in operations and maintenance costs aboard ship. There are issues to be addressed prior to making such reductions, but shipboard workload requirements and necessary technology are not impediments to resolving these issues.

NRAC (Naval Research Advisory Counsel). DAMAGE CONTROL AND MAINTENANCE (FOR REDUCED MANNING). (September 1996)

SCOPE: The Damage Control and Maintenance Panel of the Naval Research Advisory Committee (NRAQ was tasked by the Assistant Secretary of the Navy (Research, Development, and Acquisition), with the Commander, Naval Sea Systems Command (NAVSEA) as the study sponsor, to "identify science and technology opportunities as well as policy and process improvements, to reduce onboard manning for damage control and maintenance of in-service platforms." The Panel considered the "science and technology opportunities" of the Terms of Reference in the broadest interpretation, from mature and state-of-the-art to developmental. Moreover, while the study focused on "in-service platforms," most of its findings and recommendations are equally applicable to new construction, (e.g., LPD-17, SC-21, and ARSENAL SHIP).

STUDY APPROACH: The study panel consisted of 15 members from academia and industry, including retired flag officers with extensive operational experience, and also Royal Navy representation. The Panel heard briefings from a broad cross section of the Navy’s technical community on the topics of manning, damage control, and maintenance and visited several operational platforms and numerous installations, including several firefighting and damage control training facilities, the USS Yorktown, and the ex-USS Shadwell- the Navy’s principal Research and Development

(R&D) firefighting facility. The Panel also reviewed both the recent experience of the Royal Navy in their reduced manned Type 23 Frigate and the operational characteristics of Israel's SAAR-5.

MAJOR CONCLUSIONS: SMART SHIP is one of the most innovative initiatives, to date , to establish the optimum composition of levels of shipboard manpower. It is the critical first step in reducing manning and must continue to be supported at all levels of the DON.

A significantly smaller damage control crew will be a team with superior training supported by timely situational awareness information, and outfitted with user friendly, capability-enhancing damage control and communication equipment.

Reengineering of the Navy's onboard maintenance policies and practices in accordance with current knowledge and emerging technologies will significantly reduce the manpower burden, saving thousands of crew hours per week per ship.

The development of affordable sensors by utilizing micro-electromechanical systems (MENS) and wireless telemetry has the revolutionary potential to reduce ship manning across the board for both in-service and future ships. An Advanced Concept Technology Demonstration (ACTD) investment should be made to realize these benefits.

Carlow International Incorporated (Welch, DL, and Baker, CC). The Effects of Union Agreements on Design For Habitability and Quality of Life at Sea. (1996)

The major maritime unions have established labor agreements with shipping companies which have direct implications for design issues of the FTV, especially as they relate to the habitability of the vessel and the experienced quality of life at sea. In order to insure that SSTDP design efforts do not violate existing agreements, several maritime unions were contacted for assistance in defining those agreements and their implications.

Design Implications of Labor Agreements

These general labor agreements have implications for FTV design, as listed below. It should be noted that in cases where a contractual requirement was present for only one subset of a crew, i.e., engineering officers vs all officers, the requirement was applied to the larger set.

1. Officers must have individual staterooms.

2. Living quarters for officers must include a private toilet.

3. Living quarters must be air-conditioned.

4. Living quarters for officers must be at least 110 square feet, not including washroom, hall space, or bunk space.

5. Living quarters for officers must be kept separate from those furnished for licensed members of the crew.

6. Living quarters for key ratings must include private toilet. Toilets for other ratings may be shared by no more than two.

7. Every effort must be made to increase noise insulation in living quarters.

8. There must be washroom and toilet facilities for the use of Licensed Deck Officers only, Licensed Engineer Officers only, and unlicensed personnel of each division

9. There must be a dining salon or mess-room, separate from the living quarters.

10. The dining salon or mess-room must be air conditioned.

11. There must be an engineering office, with a telephone, next to the First Assistant's room.

12. There must be a telephone or other voice communication system in each officer's living quarters.

13. Steps must be taken to protect hearing in machinery spaces.

14. There must be adequate materials to reduce noise levels in passageways.

15. If there is an elevator from the living quarters area, it must go to the access door of the engine room.

16. There must be a toilet in the engine room

17. There must be a refrigerator or combination water cooler-refrigerator in the engine room.

18. There must be an automatic electric washer and drier in the immediate vicinity of the licensed officers' quarters.

19. If there is a recreation room, it must be air-conditioned.

20. Plans for quarters, habitability spaces, and equipment must be coordinated with the unions (MEBA) prior to construction and discussions of manning levels.

Carlow International Incorporated (Welch, DL, and Baker, CC). Union Perspectives on SSTDP FTV Reduced Manning Concepts. (1996)

The Appendix A discussion of the Maritime Labor Union Agreements issue reads:

Manning levels on US Flagged ships are driven to a large degree based on labor union agreements. If a ship's manning is to be reduced, new agreements with labor unions must be negotiated.

The US Naval Sea Systems Command has indicated a requirement to determine union positions regarding the effort to reduce manning levels and the safety impacts of smaller crew sizes.

Carlow International Incorporated. Sealift HSI Design for Maintainability Summary. 1996. The objectives of applying HSI to SSTDP design for maintainability are to: develop and implement a maintenance concept addressing corrective, planned, and facility maintenance which is compatible with the reduced manning levels of the SSTDP; provide design concepts, guidelines, standards and criteria to ensure that the SSTDP is maintainable under reduced manning conditions; and provide concepts, guidelines, standards and criteria to ensure effective maintenance training and usable maintenance procedures and job aids. Sealift maintenance HSI design areas include: maintenance access; maintenance workstations; labels, signs and markings; alarms and annunciators; test, measurement, and diagnostic equipment; arrangements to facilitate maintenance, and component handling, moving, and lifting equipment; location and access to spaces; communication requirements; safety design requirements; maintenance procedures and decision criteria; skill levels and maintenance training; and design of maintainability human-machine interfaces.

Malone, T.B., Baker C. C., Anderson, D. E., and Bost, R. J.. Design Approaches and Tools to Enhance the Human Factors Engineering Design of Marine Systems. (1996)

This paper presents progress in the design of advanced manning for marine systems, and progress in the development of human factors engineering (HFE) analysis and design tools that support the achievement of safe and effective HFE designs. The effort was directed at achieving safe and competitive levels of reduced manning for commercial Sealift ship, but the process and tools developed are considered to be applicable to marine systems in general.

A major contributor to the overall safety and effectiveness of marine systems is the performance and readiness of the crew. HFE initiatives are directed toward addressing personnel requirements in marine systems design. The driving objective of HFE is to influence design with personnel requirements and considerations. This is achieved through an approach that ensures that personnel considerations are addressed early in system development, that emphasizes attention to the role of the human vs. automation in system operation and maintenance, and that requires the use of simulation to model human performance and workload.

Ancillary objectives of HFE as applied to marine systems are: a) reduced manning as compared with baseline comparison systems; b) improved readiness of Sealift ships and systems due to reduced skills, reduced workloads, and task simplification; c) improved reliability of Sealift ships and ship systems due to an emphasis on software and a reduction of human error rates; d) improved personnel availability and survivability due to reduced hazards and accidents; e) enhanced system and equipment availability through reductions in time to repair; and f) enhanced system affordability, resulting from the reductions in manpower support cost, training cost, cost of systems unavailability, cost of human errors, and cost of accidents.

Tools developed as part of the effort address HFE issues and activities including: functions analysis and allocation, issue tracking, development of HFE design standards, task and operations performance simulation, selection of non developmental items, and hazards analysis.

Carlow International Incorporated (Norman, D.L.). PERSONNEL QUALIFICATION AND TRAINING TECHNOLOGY FOR SSTDP. (1996)

This report documents FY95 products for advanced manning for the Sealift Ship Technology Development Program (SSTDP) - Future Technology Variant (FTV). The report was generated to (1) document the baseline level of SSTDP manning that is the result, in part, of ongoing workload simulation studies, and (2) present significant products of the FY95 advanced manning effort.

Anderson, D.E., Oberman, F.R., Malone, T.B., and Baker, C.C.. INFLUENCE OF HUMAN ENGINEERING ON MANNING LEVELS AND HUMAN PERFORMANCE ON SHIPS. (1996)

The objectives of Human Engineering (HE) are generally viewed as increasing human performance, reducing human error, enhancing personnel and equipment safety, and reducing training and related personnel costs. There are other benefits that are thoroughly consistent with the direction of the Navy of the future, chief among these is reduction of required numbers of personnel to operate and maintain Navy ships. The Naval Research Advisory Committee (NRAC) report on Man-Machine Technology in the Navy estimated that one of the benefits from increased application of man-machine technology to Navy ship design is personnel reduction as well as improving system availability, effectiveness, and safety. The objective of this paper is to discuss aspects of the human engineering design of ships and systems that affect manning requirements, and impact human performance and safety. The paper will also discuss how the application of human engineering leads to improved performance, and crew safety, and reduced workload, all of which influence manning levels. Finally, the paper presents a discussion of tools and case studies of good human engineering design practices which reduce manning.

Anderson, D.E., Malone, T.B., and Baker, C.C.. Impacts of Reduced Manning on System Reliability and Maintainability. (1996)

The overall goal in applying human systems integration (HSI) technology to the design for ship maintainability is to ensure that maintenance requirements will be effectively and safely met in ships where available manpower has been significantly reduced compared to existing ships. HSI is concerned with defining the role of the human maintainer vs automation, identifying requirements associated with these roles, and providing design approaches for equipment, software, procedures, information, environments, communications, and organizations to satisfy the requirements. This paper will describe technologies to achieve these human system integration goals in the improvement of system reliability and maintainability.

Malone et al. Human Error Reduction through Human and Organizational Factors in Design and Engineering of Offshore Systems. (1996)

Human error represents a major threat to the safety and afford-ability of offshore systems. The IMO has reported that up to 80% of ac-cidents at sea are caused by human error. The US Coast Guard, after analyzing 340 marine casualties, also reported that human error con-tributed to at least 80% of the casualties. The IMO Secretary General concluded that "if we sincerely want to stop accidents from occurring, then I think it is obvious that we should concentrate our efforts on eliminating human error".

A major thrust of the human and organizational factors (HOF) approach to human error is directed at design of human interfaces to reduce the incidence and impact of errors. The lessons learned at Three Mile Island, Piper Alpha and other industrial accident sites is that human errors can result from inadequate equipment design, in-formation handling, emergency procedures, and training, rather than solely from inherent or transitory deficiencies on the part of the operators. The engineering design of a system has a major impact on the incidence of human errors in system operation.

Too often, the response to human error situations in industrial systems is to ignore the design of the human-machine interfaces and place the emphasis on improving training. The implication is that, having failed to consider human operator needs and limitations in the design of system equipment, the system developer integrates the operator into the system strictly by means of training. Basing operator performance on training alone when the design of the human-machine interfaces is often, from an operator point of view, illogical, in-consistent, or complex--especially in times of psychological stress as in an accident situation--is a formula for disaster.

This white paper describes the current state-of-knowledge with re-spect to the etiology of human error. Design techniques are described for preventing errors, and making systems error-tolerant, such that, if an error does occur, its impact is minimized. Design factors to be ad-dressed include aspects of the system hardware, software, procedures, organizations, facilities, jobs, communications, environments and training which affect human error likelihood.

Malone, T.B., and Baker, C.C., Anderson, D.E., and Bost R.J.. Design Approaches and Tools to Enhance the Human Factors Engineering Design of Marine Systems. (1996)

This paper presents progress in the design of advanced manning for marine systems, and progress in the development of human factors engineering (HFE) analysis and design tools that support the achievement of safe and effective HFE designs. The effort was directed at achieving safe and competitive levels of reduced manning for commercial Sealift ship, but the process and tools developed are considered to be applicable to marine systems in general.

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Tools developed as part of the effort address HFE issues and activities including: functions analysis and allocation, issue tracking, development of HFE design standards, task and operations performance simulation, selection of non developmental items, and hazards analysis.

Coast Guard: Office of Standards Evaluation and Development.. Tanker Navigation Safety Standards: Appropriate Crew Size. A Study Required by Section 4111(B)(1) of the Oil Pollution Act of 1990. (1996)

Abstract: This document presents the results gathered in response to the congressional mandate contained in Section 4111 of the Oil Pollution Act of 1990 (Public Law 101-380) to determine appropriate crew sizes on tankers. The definition of 'appropriate crew size' is based on the objective of the Oil Pollution Act of 1990, to ensure pollution prevention through safe navigation of vessels carrying hazardous substances and/or oil. The report addresses crew size and the impact of laws, implementing regulations, operating practices, ship and automation status, and potential changes thereof, on crew size.

Lewis, G. W.. Personnel Performance Workload Modeling for a Reduced Manned Bridge - Lessons Learned. (1996)

Abstract: Declining budgets and decreased military personnel strength have provided major reasons for reducing shipboard personnel. The specific objective of this project was to develop a proof-of-concept' for assessing performance workload levels of operational shipboard personnel to be used in the rapid prototyping of ship designs for reducing shipboard manning levels. A review of shipboard reduced manning efforts and development of the 'Entering San Diego Harbor' scenario are described. Personnel performance workload models, using this scenario, were developed and exercised for this project. The lessons learned in developing this scenario and moment-to-moment fluctuations in workload data are described for three bridge crew configurations. Three appendices describe a review of human performance models, additional literature related to personnel assessment technologies and personnel costs models, and the bridge team functions and tasks used in the nine member bridge team workload model. This effort showed that personnel performance workload levels can be measured under current and reduced manning levels, either with or without automated equipment Workload modeling would provide valuable information to assess current and reduced manning configurations, and operational exercises readiness. Workload modeling could contribute to the objective evaluation of automated equipment implementation and crew member reduction.

Association of Scientists and Engineers of the Naval Sea Systems Command, Washington, DC. Annual Technical Symposium of the Association of Scientists and Engineers of the Naval Sea Systems Command (33rd). Technical Papers. Golden Anniversary 1946-1996 'Forward from 50'.. (1996)

The report consists of sixteen papers in four sessions entitled 'Ships for the 21st Century,' 'Acquisition Reform.' 'Designing for the Future,' and 'Management and Logistics.' The paper topics cover oceanographic research ships, surface combatants, amphibious assault ships, cooperative engagement, oversite and review, integrated product teams, integrated product process development, system safety, commercialization, damage control, human engineering, ship habitability, electromagnetic engineering, management information systems, test end evaluation, occupational health, and regionalization. This is truly a program spanning the interests of the ASE membership as well as the mission of the Command.

Rick D. Archer, G.W. Lewis, Ph.D., John Lockett. Human Performance Modeling of Reduced Manning Concepts for Navy Ships, Proceedings Human Factors and Ergonomics Society. (1996)

WinCrew is a human performance assessment tool developed by the Army Research Laboratory, Human Research and Engineering Directorate that implements the Wickensí Theory of Multiple Resources. WinCrew supports the hierarchical decomposition of missions into functions and tasks. As a demonstration of the capability of WinCrew, simulation models of the activities performed by bridge personnel on a Navy Guided Missile Destroyer DDG51 were developed. The scenarios were chosen to illustrate the potential of task network based human performance modeling to address reduced manning issues for naval ship operations. In order to fully exercise the functionality of WinCrew, four bridge models were developed. One scenario was modeled for four different manning, automation, and task allocation configurations. The scenario modeled was entry into San Diego Harbor. The major events for the bridge team were: bearing fixes, gyro error checks, turns, precision anchoring, and obstacle avoidance. Results of the effort demonstrated the utility of workload modeling for assessing human system integration alternatives for shipboard manning.

Sperry Marine. SPERRY MARINEíS IBS REDUCES MANNING REQUIREMENTS ON US NAVYíS FIRST "SMART SHIP" (Press Release). 1996. (September 20, 1996)

The Sperry Marine Integrated Bridge System (IBS) is being applied to the USS YORKTOWN, the Navy's first "Smart Ship." "Smart Ship" is a government/industry effort aimed at significantly reducing ships' manning requirements while maintaining the highest standards of safety and operational flexibility.

National Technical University of Athens. ATOMOS (Advanced Technology to optimize manpower onboard ships) Project Rationale. (1996) http://www.deslab.naval.ntua.gr/~mtrans/mann.html

Project Summary: The merchant fleets of many countries worldwide have experienced a significant decline of competitiveness over the years. Loss of competitiveness is due to the fact that ships in these fleets are generally more expensive to operate than other ships, and shippers prefer the latter because of cost considerations. Realizing that manning costs are frequently a major percentage of ship operating costs, one of the measures that has been contemplated by many countries in order to help reverse this trend has been the design, development, and operation of highly automated ships manned by reduced crews.

The European Commission (Directorate General for Transport -DGVII), realizing the need for applied R&D in this area, sponsored project ATOMOS, within its EURET transport R&D programme. ATOMOS consists of a consortium of 9 partners from 4 EU countries (DSB Ferries Consortium Leader). The project started in early 1992 and was completed in late 1994. Its scope has been to develop advanced shipboard technologies that would enhance the competitiveness of the fleet of the EU, while maintaining an adequate level of safety.

Project Summary: THAMES (for Technological and Human Aspects of Maritime Efficiency and Safety) has been a one-year project within DGVII's APAS programme. (It spanned the period December 1994- December 1995)

The THAMES Consortium consisted of the partners of two EURET consortia: ATOMOS and MASIS. Collectively, 21 partners have been involved, of which DSB and NTUA (from ATOMOS), and Cetena and ISL Bremen (from MASIS) have been the main contractors (DSB consortium leader). The main purpose of THAMES has been to synthesize the results of the ATOMOS and MASIS projects as regards the impact of human elements on efficiency and safety. As a result, a broad variety of topics for further research in this area have been identified. These topics would be included in the Commission's future waterborne transport research plans.

Lane, Tony. Crewing the world's merchant ships. 1996. published by SIRC, University of Wales, Cardiff, 1996. The Human factor: a report on manning. (1996). published by UK P&I Club, (1996)

Rothblum, A.M., Sanquist, T.F., Lee, J.D., and McCallum, M.C.. Identifying the Effects of Shipboard Automation on Mariner Qualifications and Training and Equipment Design. (November 1995)

Abstract: Automaton is becoming more prevalent on commercial ships, affecting areas such as engineering, bridge, and cargo operations. When automation is introduced, the mariner's tasks change, which in turn may require the mariner to learn new skills in order to perform automation-assisted tasks. This paper discusses four methods which can be applied to identify the effects of automation on mariner training and qualifications: Operator Function Model Task Analysis, Cognitive Analysis, Skill Assessment, and Error Analysis. These methods are used to break a shipboard function down into its component tasks and to identify the cognitive (mental) demands of performing the function under manual and automated conditions. Any new knowledge and skills required to perform the automated task are identified, as are common errors made by mariners in the use of the equipment. Thus, these methods highlight the training and qualifications ramifications of automation, and can provide insights for improving equipment design.

Prepared for ISHFOB ’95: International Symposium - Human Factors on Board Bremen, Germany, Grabowski, Martha . Manning Project - Task Analysis Literature Review. (May 1995)

EXECUTIVE SUMMARY: Recent approaches to shipboard crew size estimation have included approaches based on tasks performed aboard ship. Incorporating these task analyses into crew size models requires databases of shipboard tasks for a variety of ship types. In order to leverage the large number of shipboard task analyses that have been conducted over the past 30 years, a literature review of shipboard task analyses was undertaken in order to determine if any of those task analyses contained useful shipboard data sets that might support the current crew size modeling project.

Investigations of shipboard crewing requirements have often involved job and task analyses of shipboard duties. The goal of many of these studies has been to develop catalogs of tasks required aboard ship, to determine times required to perform these tasks (under a variety of conditions), to aggregate those hours, and to perform a series of analyses by varying the constraints under which the data are manipulated. The purpose of this report is to describe such task analyses, in order to leverage related task analysis work, and to determine if applicable methods, data, findings, or lessons learned could be applied to the current manning model effort.

This report contains descriptions of several shipboard task analyses, as well as a number of other related studies. Each task analysis or study reported on is described in terms of its method(s), findings, and applicability to the current manning model project, including applicable data sets contained in the reports.

Portions of the studies reviewed, including their data sets, are very helpful to the current manning model project. In particular, the data and background of the Stanwick (71) and National Technical University of Athens (93) reports, the safety contribution concept of the Stoehr and Paramore (76) report, and the detailed (albeit duplicative of the current project) data provided in the PRC (92) report are of greatest utility to the current project. The nature of that utility, however, is of importance: these studies are most useful as background and cross references to the current manning model project, rather than as the bases for future data gathering or development.

It is not recommended that any of the data sets contained in the reports reviewed be used as a baseline data set which could be supplemented by a current manning model data gathering effort. The current manning model project has developed a rather mature set of tasks, data structures, data definitions, and attributes (duration, frequency, period, time scheduled, priority, etc.) that are fundamental to a robust manning model implementation. Rather than attempt to backfit an existing partial data set to the current manning model project’s tasks, data structures, data definitions, and attributes, it is recommended that a "clean" data gathering effort be undertaken--for the vessel, voyage and operational characteristics desired--in order to implement the structures of the model thus far defined. Since none of the studies reviewed "fit" the current manning model project’s tasks, data structures, data definitions, or attributes exactly, and since such a fit is critical to a successful implementation of a robust manning model, new data gathering efforts are recommended, rather than use of the partial data sets contained in the studies reviewed.

US Coast Guard. Prevention Through People: Quality Action Team Report. (July 1995)

Human error causes more than 80 percent of marine casualties. These human error causes have not been addressed directly; the majority of maritime safety resources focus on eliminating accidents by reducing material failures and systems problems. The Office of Marine Safety, Security and Environmental Protection (G-M) in partnership with the Office of Navigation Safety and Waterway Services (G-N) chartered a Prevention Through People (PTP) Quality Action Team (QAT) to develop a long-term strategy to rebalance the safety equation by refocusing prevention efforts on casualties caused by human error. This report is the result of the PTP QAT’s work. The report examines the extent of human error in the maritime transportation system; identifies candidate, high risk industries where human error prevails; examines the reasons why human error persists; offers a strategy to refocus prevention efforts on human error, root causes of marine casualties, and recommends an implementation plan to create a participatory, systematic approach to reduce human error-related loss of life, injury, and pollution.

American Society for Testing and Materials. Standard Practice for Human Engineering Design for Marine Systems, Equipment and Facilities. (August 1995).

SCOPE

1.1 This practice establishes general human engineering design criteria for marine vessels, and systems, subsystems, and equipment contained therein. It provides a useful tool for the designer to incorporate human capabilities into a design.

1.2 The purpose of this practice is to present human engineering design criteria, principles, and practices in order to achieve mission success through integration of the human into the vessel system, subsystem, and equipment with the goals of effectiveness, simplicity, efficiency, reliability, and safety for operation, training, and maintenance.

1.3 This practice applies to the design of vessels, systems, subsystems, and equipment. Nothing in this practice shall be construed as limiting the selection of hardware, materials, or processes to the specific items described herein. Unless otherwise stated in specific provisions, this practice is applicable to design of vessel systems, subsystems, and equipment for use by both men and women.

1.4 Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.

1.5 This practice is pot intended to be a criterion for limiting use of material already in the field in areas such as lift repetition or temperature exposure time.

1.6 Force limits-If it is known that an item is to be used by an already established occupational specialty, for which physical qualification requirements for entry into that specialty are also established, any discrepancy between the force criteria of this practice and the physical qualification requiremenu shall be resolved in favor of the latter, In this event, the least stringent physical qualification requirement of all specialties which may operate, maintain, transport, supply, move, lift or otherwise manipulate the item, in the manner being considered, is selected as a maximum design force limit.

1.7 Manufacturing tolerances-When manufacturing tolerances are not perceptible to the user, this practice shall not be construed as preventing the use of components whose dimensions are within a normal manufacturing upper or lower limit tolerance of the dimensions specified herein.

Carlow International Incorporated (Baker, C.C.). Human System Integration Detailed Design Guidance for SSTDP. (1995)

1.1 This practice establishes general human-system integration (advanced manning) design guidance to support the detailed design of human interfaces for the Strategic Sealift Technology Development Program (SSTDP). It provides a useful tool to aid the designer in incorporating human capabilities into a design.

1.2 The purpose of this design guide is to present human engineering design criteria, principles, and practices in order to enhance SSTDP efficiency and safety of operations and maintenance through integration of the human into the SSTDP system, subsystem, and equipment with the goals of effectiveness, simplicity, efficiency, reliability, and safety for operation, training, and maintenance.

1.3 Manufacturing tolerances - When manufacturing tolerances are not perceptible to the user, this practice shall not be construed as preventing the use of components whose dimensions are within a normal manufacturing upper or lower limit tolerance of the dimensions specified herein.

Carlow International Incorporated (Welch, DL, and Baker, CC). US Coast Guard Perspectives on SSTDP FTV Reduced Manning Concepts: The Marine Safety Manual- Review Draft – (1995)

The Appendix A discussion of the diverse laws, regulations and requirements issue reads in part:

There are numerous laws and regulations governing ship manning, including the CFRs (for example 33, 46), acts of Congress (OPA 90 rules 15/24 and 36/72 addressing work hours), and private (certification and insurance) that must be reconciled in order to achieve manning levels of ten or fewer crew.

Table 1 lists the statutes and implementing regulations related to the manning of inspected and uninspected vessels, as considered by the US Coast Guard (USCG). The Secretary of the Department of Transportation (SECDOT) has authorized the Commandant of the USCG to perform the functions required of the SECDOT by these laws. This authority has been further delegated in Part 1 of Titles 33 and 46, Code of Federal Regulations (CFR), the USCG Marine Safety Manual (MSM) (US Coast Guard, 1995), and USCG instructions issued to marine safety personnel.

The general regulations for manning of vessels are contained in 46 CFR 15 (Subchapter B, Merchant Marine Officers and Seamen). Under 33 CFR 1.01-20, the USCG Officer in Charge, Marine Inspection (OCMI) is responsible for the enforcement of vessel inspection, navigation, and seamen's laws within a specific zone. In this capacity, the OCMI is responsible for certifying the competence of merchant mariners and for establishing manning levels for various types of vessels. The Certificate of Inspection (COI) Form CG-841 states the minimum number of licensed officers and certified crewmembers necessary for the safe operation of inspected vessels, as required by Title 46 of the U.S. Code (U.S.C.) 8103, 8104, 8304, 8701-8703, 8903, and 8904.

Hill, S.G., Byers, J.C., Rothblum, A.M., Booth, R.L.. "Gathering and Recording Human-Related Causal Data in Marine and Other Accident Investigations" in Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting, 1994, 863-867. (October 1994)

One of the missions of the U.S. Coast Guard (USCG) is to pormote safety at sea through the prevention os marine accidents. One means of preventing accidents is through the thorough investigation of the causes of marine casualties, the analyses of which can illuminate needed safety improvements. A study was conducted with the purpose of learning more about the USCG casualty investigation process, analyzing the data entry process, and making recommendations for improvements to the current computer system and the casualty investigation process. The study identified four major factors in the USCG system, particularly related to the reporting of human-related causes, which may have broad application to other safety professionals who contemplate the use of similar automated reporting and analysis systems. These widely applicable factors were:

- the reliability and completeness of the data can be affected by investigators' understanding of the purpose and scope of the accident database;
- the collection of human factors data can be overlooked and oversimplified;
- the taxonomy/classification scheme affects data collected as well as data reported;
- the computer interface used for data entry can affect the reliability, validity, and completeness of the data.

Akerstrom-Hoffman, R.A., and Smith, M.W.. "Mariner Performance Using Automated Navigation Systems,"in Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting, 1994, 868-872. (October 1994)

Electronic Chart Display and Information Systems (ECDIS) technology has recently emerged as a promising aid to maritime navigational safety and operational efficiency. ECDIS is likely to have multiple effects on the tasks bridge personnel must perform. However, careful consideration must be given to safety in adopting this new technology. A ship-handling simulator-based evaluation of some human factors aspects of the use of ECDIS is presented. The issues discussed include the effect on navigational safety and workload as a result of introducing ECDIS to the bridge: navigating a planned route, responding to harbor traffic, and managing the preparations for arrival or departure. During "baseline" transits, conventional methods were available to the mariner. During test scenarios, one of two prototype ECDIS systems was also added to the bridge. Under certain conditions, ECDIS reduced the mariner's workload for navigation. In addition, ECDIS showed a potential to increase safety as measured by a smaller cross-track distance from the planned route and by a larger proportion of time available to devote to collision avoidance and "look-out."

Lee, J.D., and Morgan, J.. "Identifying Clumsy Automation at the Macro Level: Development of a Tool to Estimate Ship Staffing Requirements," in Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting, 1994, 863-867. (October 1994)

Automation promises increased operating efficiency and suggests the opportunity to reduce the number of people required to operate commercial ships safely; however clumsy automation may degrade safety and performance, rather than enhance it. This paper distinguishes between clumsy automation at the macro level and clumsy automation at the micro level, and discusses macro level issues. Specifically, macro level clumsy automation refers to the failure to consider the broad implications of automation induced crew reductions. Clumsy automation may reduce workload and facilitate crew reductions during routine sailing, but these crew reductions may leave the vessel more vulnerable to unacceptable workload peaks during unusual and emergency situations (fires, unscheduled maintenance, rough seas, reduced visibility). In these situations, tasks not accommodated but he automation may overwhelm a crew that has been reduced due to the introduction of automation. Currently, no systematic procedure exists to estimate the changes that automation implies for staffing levels and skill requirements. Avoiding the effects of clumsy automation depends on identifying techniques to broaden the study of automation to include the effects on the entire crew through all phases of ship operation. This paper describes a computer-based tool to help identify potential overload situations that would be difficult to anticipate through intuitive assessments of how automation and other factors affect crew environment.

Naval Sea Systems Command (NAVSEA). Sealift Technology Development Program (SSTDP) Future Technology Variant (FTV) Mk 0. (October 1994).

Executive Summary: The Sealift Technology Development Program (SSTDP) Future Technology Variant (FTV) Mk 0 Report summarizes the FY '94 efforts of the SSTDP team. The FTV Mk 0 is a convertible RO/RO - containership concept based on the threshold requirements of the draft COM-20 ORD (June 1992). The FTV is designed to commercial standards (ABS, USCG, IMO, etc.), and address several needs of commercial owners/operators as derived from MarAd's 1992 survey (PANAMAX beam, 200 meter overall length limit, 1,500 to 2,000 TEU container capacity). The FTV retains the national Defense Features (NDFs) and military RO/RO capability, but is rapidly convertible to a more commercially acceptable containership.

The first volume of this document contains the description of the FTV concept and a summary of the FY '94 technology development efforts, including a description of each technology and its demonstrable benefits. The second volume (Appendices) contains the details of the concept design.

The presently documented Mk 0 concept will lead to the Mk 1 design in FY '95 and several features will be examined. Examples are deck crane capability, further reduction in manning, sideport ramps and removal of hydraulic actuators for the flexible cargo system. Focus will be on those systems which would improve the FTV's commercial viability.

Naval Sea Systems Command (NAVSEA). Sealift Technology Development Program (SSTDP) Future Technology Variant (FTV) Mk 0 - APPENDICES. (October 1994)

Executive Summary: The Sealift Technology Development Program (SSTDP) Future Technology Variant (FTV) Mk 0 Report summarizes the FY '94 efforts of the SSTDP team. The FTV Mk 0 is a convertible RO/RO - containership concept based on the threshold requirements of the draft COM-20 ORD (June 1992). The FTV is designed to commercial standards (ABS, USCG, IMO, etc.), and address several needs of commercial owners/operators as derived from MarAd's 1992 survey (PANAMAX beam, 200 meter overall length limit, 1,500 to 2,000 TEU container capacity). The FTV retains the national Defense Features (NDFs) and military RO/RO capability, but is rapidly convertible to a more commercially acceptable containership.

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Carlow International (Baker, C.C.). Sealift Technology Human-System Integration (HSI) Issues. (May 1994)

This report addresses the human factors engineering (HFE), safety, and manpower, personnel and training (MPT) issues related to the design and development of next generation Sealift ships.

Melber, B., Hauth, J., Terrill, E., Berk, B., and Gore, B. . An International Comparison of Commercial Nuclear Power Plant Staffing Regulatins and Practice 1980-1990. (March 1994) .

Abstract: In this report an international review of regulatory and industry practices is provided in the area of nuclear power plant staffing during the 1980s in Canada, France, Germany, Japan, Sweden, and the United Kingdom. The objective of this review is to highlight trends in staffing regulatory approaches, industry practices, and issues of concern in other countries that have potential relevance to nuclear power plant staffing issues in the United States.

The decade of the 1980s was marked by a great deal of growth in nuclear power operations internationally; however, growth of nuclear power is not expected to continue in the 1990s except in France and Japan. A continuum of regulatory approaches to staffing was identified, ranging from prescribed regulations that are applied to all licensees (Germany is most similar to the United States in this regard), to indirect staffing regulations where the regulatory authority oversees plant operating practices that are agreed to in the plant operating license (most notably, France and the United Kingdom). Most of the changes observed in staffing regulations and practices in the early 1980s were made in response to the accident at the Three Mile Island Unit 2 nuclear power plant (TMI) in 1979. These changes included the widespread issuance of new operator and licensing requirements and the establishment of national training centers. After the post-TMI changes were implemented, a period of relative stability followed. Changes in the latter half of the 1980s have focused on continuing improvements and additions to training curricula and methods, most notably increased reliance on simulator training.

Sanquist, Thomas F. and Lee, John D.. Cognitive Analysis of Navigation Tasks: A tool for Training Assessment and Equipment Design. (April 1994) (Interim).

Abstract: Automation is becoming more prevalent on commercial ships. When automation is introduced, the mariner's tasks change. Certain manual tasks may no longer be required, and there are new tasks specific to the operation of the automated system. In some cases, tasks which were formerly performed by two or more mariners are now combined into the responsibility of a single crew member. As the knowledge and skills required to operate a vessel change, the U.S. Coast Guard currently lacks a systematic approach for determining the effects of new automation on mariner qualifications.

This paper presents an over view of four different, but complementary, methodologies being developed to assess how a given automation system changes shipboard tasks and the knowledge and skills required of the crew. The report focuses on one of these methods, a powerful new application of cognitive analysis. Cognitive analysis identifies the mental demands (such as visual detection, computation, and memory) placed on the mariner while performing shipboard tasks can highlight differences in the knowledge, skills, and abilities required to perform that tasks. Thus, cognitive analysis identifies changes which may be needed in training and licensing/certification as a result of shipboard automation. The body of the report is a technical documentation of the cognitive analysis method.

Sanquist, T.F., Lee, J.D., and Rothblum, A.M.. Cognitive Analysis of Navigation Tasks: A Tool for Training Assessment and Equipment Design. (April 1994)

Abstract: Automation is becoming more prevalent on commercial ships. When automation is introduced, the mariners tasks change. Certain manual tasks may no longer be required, and there are now tasks specific to the operation of the automated system. In some cases, tasks which were formerly performed by two or more mariners are now combined into the responsibility of a single crew member. As the knowledge and skills required to operate a vessel change, the U.S. Coast Guard needs to reflect these changes in its qualifications and licensing/certification requirements. However; the U.S. Coast Guard currently lacks a systematic approach for determining the effects of new automation on mariner qualifications.

This paper presents an overview of four different, but complementary, methodologies being developed to assess how a given automated system changes shipboard tasks and the knowledge and skills required of the crew. The report focuses on one of these methods, a powerful new application of cognitive analysis. Cognitive analysis Identifies the mental demands (such as visual detection, computation, and memory) placed on the mariner while performing shipboard tasks. A comparison of the mental, demands associated with manual versus automated tasks can highlight differences in the knowledge, skills, and abilities required to perform the tasks. Thus, cognitive analysis identifies changes which may be needed in training and licensing/certification as a result of shipboard automation. The body of the report is a technical documentation of the cognitive analysis method.

Shell Offshore, Inc. (Gerry Miller). MARS project - Vendor labeling. (1994)

Defines requirements for preparation and installation for those labels which the vendor a) is directed by Shell Offshore, Inc. to provide, or b) elects to prepare and install on equipment for use on MARS TLP -- not for identification labels on wiring and standard manufacturing nameplates.

National Research Council, Washington, DC. Minding the helm: Marine navigation and piloting. . (1994)

The marine transportation system has come under intense public scrutiny as a result of recent marine accidents involving substantial spillage of oil and damage to the marine environment. This report focuses on the role of marine navigation and piloting in minimizing the number of accidents. It examines what can be done to reduce operational, economic, and environmental risks through improvements to navigation and piloting technology and practices in the nation's ports and waterways and their coastal approaches. Manning/Navigation/Ships/Commercial/Safety/.

International Maritime Organization. International Safety Management Code. (1994)

The purpose of this code is to provide an international standard for the safe management and operation of ships and for pollution prevention.

Recognizing that no two shipping companies are the same, and that ships operate undera wide range of different conditions, the Code is based on general principles and objectives

The Code is expressed in broad terms so that it can have a wide-spread application. Clearly, different levels of management, whether shore-based or at sea, will require varying levels of knowledge and awareness of the items outlined.

The cornerstone of good safety management is commitment from the top. In matters of safety and pollution prevention it is the commitment, competence, attitudes and motivation of individuals at all levels that determines the end result.

International Maritime Organization. Convention on Facilitation of International Maritime Traffic, 1965. 1994. The present publication contains the text of the Convention effective on 1 (September 1993)

It also includes the texts of various resolutions which were adopted by the 1965 Conference, the text of a resolution adopted by the Assembly of the Organization on 19 November 1987 (resolution A.628(15)) and additional information on facilitation requirements, namely the IMO FAL forms, Simpler Shipping Marks, IMDG Code -- Documentation of Dangerous Goods Shipments, the format of the letter referred to in Standard 3.3.1, a list of certificates and documents required to be carried on board ships and a supplement relating to the annex to the FAL Convention containing information on notifications by States Parties to the Convention concerning differences betwen national practices and Convention Standards and concerning the adoption of Recommended Practices.

International Maritime Organization. International SafetyNET Manual. (1994)

SafetyNet is an international automatic direct-printing satellite-based service for the promulgation of navigational and meterological forecasts and other urgent safety-related messages -- maritime safety information (MSI) -- to ships. It has been developed as a safety service of the International Maritime Satellite Organization's (Inmarsat) enhanced group call system to provide a simple and automated means of receiving MSI on board ships at sea and in coastal waters, where appropriate. The information transmitted is relevant to all seagoing vessels and the message-selaction features ensure that mariners can receive safety information broadcasts which are tailored to their particular needs.

Carlow International, Inc.. Human Systems Integration for the New Attack Submarine (NAS). (September 1993)

HSI strategy is to identify major operating and support cost drivers of overall NAS program. Overall goal is to influence NAS design to maximize effectiveness of human component to prevent it from being a weak link.

2.0 NAS Program Description

3.0 HSI Program Description

3.3 Phase 0

3.4 Phase 1

3.5 Preliminary HSI Analysis Results

3.6 HSI Testing and Evaluation Requirements

3.7 HSI Activities Completed

Henn, A.E.. "A Partnership in Maritime Evolution" from Maritime Reporter/Engineering News. (October 1993)

USCG is striving toward a safe and clean marine environment

4 "Safety Nets" of protection that keep a ship and its passengers, crew, and cargo safe

Net 1 - Owners and Operators

- IMO and MSC have taken note of importance of maritime community's infrastructure - ISM codes recommend "appropriate organization of management" expected to be adopted Oct. 1993

Net 2 - Classification Societies

- Responsible to owner for ensuring ship complies w/ requirements of own classification rules. Too many "in name only" classif. soc.

Net 3 - Flag state administration

- Responsible for ensuring that provisions of such laws and regulations are met. USCG is the Flag state administration for US ships.

Net 4 - Port State

- Authority to verify that provisions of convention are met. Role is to verify not certify condition of ship.

"USCG is tired of being the only policemen for worldwide maritime safety"

National Transportation Safety Board. Marine Accident Report: Grounding of the United Kingdom Passenger Vessel RMS QUEEN ELIZABETH 2. (March 1993)

On august 7, 1992, the United Kingdom passenger vessel RMS (Royal Mail Ship) QUEEN ELIZABETH 2 was outbound in Vineyard Sound, Massachusetts, when the vessel grounded about 2 1/2 miles south of Cuttyhunk Island. No injuries or deaths resulted from this accident. However, damage was significant; temporary and permanent repairs cost about $13.2 million. In addition, the total revenue lost for the period before the vessel returned to service on October 2, 1992, was estimated at about $50 million.

In this report the following safety issues are discussed: the adequacy of shipboard communication; the adequacy of bridge resource management, the adequacy of squat information; the adequacy of navigation chart survey information; the adequacy of Coast Guard instructions to field personnel for drug and alcohol testing of personnel involved in accidents; and the adequacy of shipboard evacuation procedures for disabled passengers.

As a result of its investigation, the Safety Board made recommendations addressing these issues to the U.S. Coast Guard, Department of Transportation, National Oceanic and Atmospheric Administration, Cunard Lines, Ltd., and the State pilot commissions.

Miller, G.E. . Human Factors Engineering (HFE) Review of International Maritime Organization (IMO) Documents COLREG 1972, and the Manual on Oil Pollution Prevention, Section I. (June 1993).

As part of the on-going review of existing federal and international ship design and operating regulations which might contain human factors engineering requirements , a detailed analysis was completed on two International Maritime Organization (IMO) publications:

1. Convention on the International Regulations for Preventing Collisions at Sea, 1972, IMO-904-E
2. Manual on Oil Pollution Prevention, Section 1, IMO-557E.

Each document was examined to determine if:

1. they possessed any HFE type ship design or operation requirement,
2. they did, did the requirement(s) match accepted HFE marine HFE design standards (e.g. ASTM F1166-88)
3. the HFE requirements existed were they of the type that would likely contribute to an oil pollution type incident if ignored by ship owners or operators in the design and/or operation of their ships, and
4. the requirements did exist were they of the type that could be easily verified and enforced by Washington State's Office of Marine Safety (OMS) to reduce potential accidents in the State's waters resulting in oil spills.

Weber, Paul T. Memo to Henry S. Marcus re Trip aboard COLLEEN SIF. (Jan 1993).

Outlines information about the Knut I. Larsen COLLEEN SIF observed on Jan 9, 1993 by Paul Mentz, Richard Schubert, and Alexander Landsburg.

Crew Breakdown

Mooring

Automation -- Bridge

-- Engine room

-- Control consoles

-- Reliability

Workload

Remuneration

Training

Emergency Drills

Effects of Company Policy

Conclusions; Applicability to our research

Levels of Automation and Technology

Sanquist, T.F., and Lee, J.D. Human Factors Plan for Maritime Safety (with Bibliography). (February 1993)

Abstract: Purpose of report is to present an integrated plan of human factors work oriented toward effectively implementing HF in the USCG, the maritime industry and IMO. Objectives: 1) identify HF issues affecting regulatory, guidance and enforcement activities of the CG, 2) determine interrelationships between issues, and 3) propose specific HF solutions.

Lee, J., and Sanquist, T. Modeling Techniques for Shipboard Manning: A Review and Plan for Development. (February 1993).

Abstract: The worldwide trend in shipboard manning is toward increasingly smaller crew sizes. One concern regarding smaller crews is to what extent they may compromise ship safety and the ability to respond in an emergency. In order to address this concern, one needs a systematic method of establishing safe crew complements that can be applied on an international basis. Manning models can provide a flexible, economic method for establishing safe manning levels. This report critically analyzes existing manning models, both within and outside the maritime domain. A detailed examination of six models developed for the maritime domain illustrates how limits associated with tools and content, as well as the complexity and diversity of issues involved with manning requirements, make it difficult to use any of these six models as a technical basis for all ship manning decisions. Rather than develop a single, comprehensive manning model, it is suggested that the wide variety of issues related to safe manning may require a number of specialized models, each of which is used to examine specific issues.

Grabowski, M., and Roberts, K.H.. Human and Organizational Error in Large Scale Systems. (August 1993)

Thesis: We cannot fully understand the complex social processes that underlie either the reliable or unreliable operations of complex social/technical systems w/o examining the systems in their totality.

Purpose: Identify the determinants of behavior most important in understanding the operation of large-scale systems in highly turbulent environments.

PRC for DOT -- MA-RD-840-93005. Sealift Technology Development Program Assessment of Advanced Manning Technology Vols. I and II - Final Report. (August 1993).

Abstract: Assesses the advancement of manning technology and explores the possibility for manning of the Mid-Term Sealift Ship design concepts. Alternative manning levels and the technology development initiatives required to bring about these levels were identified. Automation technology addressed was grouped into five levels. A numerical analysis of work rationalization was performed using subjective quantifications if the impacts of technical enhancements and automation. The economic and safety aspects of these initiatives and the practicality of implementation were addressed. The report concludes with findings and recommendations derived from these analyses.

Ogden Government Services for Office of Marine Safety State of Washington. Evaluation of Existing Human Factors Engineering (HFE) Design Requirements for ships Entering Washington Waters. (April 1993).

There may be a plethora of HFE based federal standards for ship operation and design but if they are not being enforced by the USCG through their vessel inspection program, they provide no protection to Washington State waters. On the other hand, if standards do exist, and they are being enforced, they could reveal and control HFE deficiencies in both vessel operations and design which would make vessel accidents in this region much less likely. Further, it would reduce or perhaps even eliminate the need for OMS to conduct vessel operations. Even if HFE deficiencies do exist on vessels entering Washington waters however, it is understood that any OMS vessel inspection program may have restricted capability to eliminate these deficiencies. The correcting of some detected design or operational deficiencies such as proper wording of warning signs or the non-use of operating manuals during oil loading/unloading as required by the CFRs should be within OMS's capability. However, demanding a redesign of the alternate steering gear room on all vessels entering Washington waters to correct a significant HFE design deficiency most likely will not be achievable directly through OMS because of the cost associated with correcting this important HFE design flaw.

NRC. Workload Transition. (1993).

Pertinent Sections:

1. Team Transitions (p.13)

3. Workload (p.54)

5. Sleep Disruption and Fatigue (p.122)

9. Strategic Task Management (p.214)

10. Team Leadership and Crew coordination {mainly aviation} (p.229)

11. Training for emergency responses (p.248)

- Maritime and Coast Guard (p.39-45) -- less precise and largely informal decision making structure - communication is more informal and does not have brevity and clarity and accuracy of Naval Communications

-> contains brief description of crew size, organization, tasks, command structure, schedules.

Gumpell, S., Germanischer Lloyd: R&D Helps Pave the Way for Safety" from Maritime Reporter/Engineering News. (1993). [incomplete document].

US DOT -- MARAD. Sealift Technology Development Program - Assessment of Cargo Handling Technology, Vol. II, Final Report. (1993).

Provides the results of an engineering cost/benefit evaluation of potential cargo handling technologies of the future. It evaluates the cost and benefits of each of the ship convertible concepts and the future cargo handling technologies identified in Vol. 1, Technology Assessment Reports. Results of this report provide a basis for the identification of convertible and future technologies that could potentially improve the productivity of current cargo handling technologies.

Objective was to evaluate the productivity of each cargo handling concept identified in the Technology Assessment Report. 5 convertible concepts and 12 future concepts were evaluated. All costs associated with using each concept to move commercial cargo were identified and estimated. Costs included were Acquisition Cost, Development cost, Maintenance cost, Operational cost, and Ship Modification costs.

Future cargo handling concepts were compared against today's technology using the commercial CRS 14 as a baseline. This analysis was based on evaluating the ability of the concept to move containerized cargo. RO-ROs weren't included in this comparison.

3 Future cargo handling systems showed a cost savings over the baseline CRS 14, which operated at $261 per container: Shelfship-Shelftainer, RO-RO, and the overhead crane.

Final objective was to evaluate concepts in regard to the ability to support military sealift requirements. This analysis demonstrated all of the convertible concepts in their converted RO-RO mode, provide a comparable level of sealift support.

Shell Offshore, Inc. (Gerry Miller). Vertical ladder, railing, stair, and walking design and location specification for the Mars TLP. (1993).

1.0 Stairs

2.0 Vertical ladders

3.0 Steps

4.0 Individual ladder rungs

5.0 Ramps

6.0 Elevated work platforms

7.0 Walkways

8.0 Handrails for walkways and platforms

International Maritime Organization. International Convention on Standards of Training, Certification and Watchkeeping, 1978 (STCW 1978). (1993).

The International Convention on Standards of Training, Certification and Watchkeeping, 1978 (STCW 1978), was adopted by the International Conference on Training and Certification of Seafarers on 7 July 1978 and entered into force on 28 April 1984.

On 22 May 1991 the Maritime Safety Committee adopted amendments to SCTW 1978 by resolution MSC.21(59), in accordance with article XXI(1)(a)(iv) of the Convention. The amendments entered into force on 1 December 1992.

This publication contains a consolidated text of SCTW 1978, incorporating the above requirements.

PRC Data Services Co. Sealift Technology Development Program: Assessment of Advanced Manning Techniques. Volume 2, Appendix H (Final report). (1993).

This report, provided in two volumes, assesses the advancement of manning techniques and explores the possibilities for manning of the Mid-term Sealift Ship design concepts. Alternative manning levels and the technology development initiatives required to bring about these levels were identified. Automation technology addressed was grouped into five levels. A numerical analysis of work rationalization was performed using subjective quantifications of the impacts of technology enhancements and automation. The economic and safety aspects of these initiatives and the practicality of implementation were addressed. The report concludes with findings and recommendations derived from these analyses. This is Volume 2 of 2.

PRC Data Services Co., Reston, VA.. Sealift Technology Development Program: Assessment of Advanced Manning Techniques. Volume 1. Final Report. (1993).

This report, provided in two volumes, assesses the advancement of manning techniques and explores the possibilities for manning of the Mid-term Sealift Ship design concepts. Alternative manning levels and the technology development initiatives required to bring about these levels were identified. Automation technology addressed was grouped into five levels. A numerical analysis of work rationalization was performed using subjective quantifications of the impacts of technology enhancements and automation. The economic and safety aspects of these initiatives and the practicality of implementation were addressed. The report concludes with findings and recommendations derived from these analyses. This is Volume 1 of 2.

Levine, D. B. ; Horowitz, S. A. Savings in Operating Costs and Billets From Civilian Manning of Navy Underway Replenishment Ships. (1993).

This paper shows that the Navy could save considerable cost and billets by operating more of its underway replenishment ships with civilian mariners under the Military Sealift Command (MSC). By transferring to MSC all of the replenishment ships still under Navy operation, the Navy would save between 10,000 and 12,000 billets and between $280 million and $380 million in annual operating cost. The variation is due to two uncertainties not estimated by the study: the sea-shore rotation statistics of the shipboard ratings (the Navy's target of no more than 50 percent of the time at sea is often not met), and the essentiality of the tasks the shipboard ratings perform while ashore. Using small civilian crews sometimes raises Navy concerns about issues such as ship safety and personnel availability, productivity, and reliability. However, the recent experience of replenishment ships operated by the Navy, MSC, and the British Royal Fleet Auxiliary provides little evidence to support such fears.

Lee, J. D. ; Sanquist, T. F. Modeling Techniques for Shipboard Manning: A Review and Plan for Development. (1993).

The issue of shipboard manning scales is a complicated legal, economic and human factors engineering question. The worldwide trend in shipboard manning is toward increasingly smaller crew sizes - in the case of some Japanese ships, crews are composed as few as 11 persons. Crew sizes of this level are made possible by advanced technologies permitting unmanned engine rooms and one-man bridge operation, as well as reductions of deck crew for cargo handling. A fundamental question that arises as a result of such crew reductions is the extent to which smaller crews compromise ship safety and the ability to respond in an emergency. This question has not been addressed satisfactorily. There is a need for a systematic method of establishing safe crew levels that can be applied on an international basis. A number of authors share this opinion, but at this time no comprehensive approach has been established. Several issues make the need for a model of ship manning increasingly important. Most generally, they involve understanding how reduced or modified staffing influences ship safety. The general issue of ship safety involves several more specific concerns, such as the effects of increased technology, emergency response effectiveness, and maintenance capabilities. In establishing safe crew levels, the government and industry need to consider demands on the crew, each vessel's technology, type of service, crew skills, and quality of management and management programs. Evaluating how these, and other issues affect ship safety provides a crucial step toward developing a technical basis for Coast Guard policy.

HUMAN FACTORS PLAN FOR MARITIME SAFETY: ANNOTATED BIBLIOGRAPHY; INTERIM REPT. (1993).

ABSTRACT: This report summarizes a collection of papers related to the application of human factors to the maritime industry. These papers describe: human factors problems in the maritime industry, research designed to offer solutions, and research in other domains that may apply to these and other potential problems encountered in the maritime industry. This report has been divided into six sections, each dealing with a particular area of interest: automation, fatigue/incapacitation, manning, navigation, organizational factors, and training. Each summary includes the complete citation, a synopsis of the methodology used, issues addressed, principal findings, and any technical problems or deficiencies.... Maritime safety, Manning, Automation, Navigation, Fatigue, Organizational factors, Incapacitation, Training.

Mentz, Paul . Notes on Trip to the COLLEEN SIF. (January 1992).

A visit was made to the COLLEEN SIF at Port Everglades Florida on January 9, 1992 by Mr. Paul B. Mentz, Mr. Richard Schubert and Mr. Alexander C. Landsburg. The COLLEEN SIF is the 3rd of 3 sister ships operated by Knud I. Larsen in charter to Sea-Land Service, Inc. The ships are a product of the Danish "Ship of the Future" project and feature many innovations.

Marine Index Bureau (Fax from David Kennedy to Fred Oberman). UK Club's Analysis of Major Claims. (1992).

Analysis of claims and 1st phase of ship visit program claims were: Officer error- 25%, crew error -16%, equipment failure - 11%

Error = any human action or omission identifiable as the immediate cause of an accident

Aside from knowledge and experience deficiencies and temperamental conditions, Pride (macho), confusion, fatigue, math errors are also cited as sources of error.

USCG R&D Center. Human Factors Research and Development (FY 92-94). (1992).

Objectives of Program: To develop a total systems approach to study of marine system to understand the human factors that can affect performance and lead to casualties, and to apply the knowledge gained to improve design, training, staffing, licensing, and operational procedures.

Acquisition Related HF (to replace aging fleet) -- Norwegian SAR boat "live-aboard" concept; Operational T&E of the 47MLB (rescue Craft). NATO Defense Research Group. Analysis Techniques for Man-Machine Systems Design V.1. (1992).

Abstract: Human engineering (known in some countries as human factors in design or ergonomics) is a discipline by which data on human capabilities and limitations are taken into account during the engineering design and development process. NATO AC/243 (panel 8/RSG.14) completed a study of analysis techniques used for human engineering. The RSG collected information on the known human engineering analysis techniques, compiled descriptions of thirty-one existing techniques, reviewed the current state of standardization of such techniques, and compiled examples of functional decompositions of typical manned systems. The two volumes of this report review the state-of-the-art of human engineering analysis and its relationship to systems engineering.

Carlow International, Inc. (Perse, R.M, and Baker, C.C.). HSI Assessment for Accommodating Women on the DDG-51 Class. (1992).

Results

1. Overhead gate valves, etc. are often out of reach for 5th percentile women

2. battle dress/firefighting clothing is large and ill fitting

3. egress from scuttles is impossible for 5th percentile women (hatches too heavy)

4. Women unique medical requirements

5. no women's sanitary items

6. flight deck safety net - critical safety factor
7. engaging/disengaging anchor windlass wildcat on fo'csle is hazardous
8. SRBOC chaff launcher is overhead and difficult to operate
9. JBox interferes with hand cranking on deck
10. bulkhead first aid box in scullery too high
11. AFFF systems tanks difficult to access and service
12. Peloruses are too high
13. Loss due to pregnancy

"MHI Bridge System Uses Artificial Intelligence" from Marine Log, p. 55. (1992).

Mitsubishi Heavy Industries has a new artificial intelligence-based ship bridge operation support system that automatically warns of potential for collision or groundings. Super Bridge is designed to enable 1 person to be able to operate the bridge. Super Plant is designed for monitoring and maintaining the engine room and other parts of the ship's plant. Super Cargo is designed for support cargo handling and scheduling. Combined systems are called Super ASOS (Super Advanced Ship Operating System) and is being installed on Japanese ships.

Parrish, Michael . "Since Exxon Valdez, Fewer Oil spills -- Decline Attributed to Tougher US Laws, More Cautious Shippers" from The Washington Post. (1992).

Reduced major oil spills since 1989. In 1991, there were 3 spills totaling only 55K gallons, according to "oil spill expert" Richard Golub (also president of World Information Systems) Tanker advisory Center has noticed a slight improvement in safety of chartered tankers entering US waters since the Oil Pollution Act of 1990 (ranked 3.4 in 1989, 3.6 in 1990). Petroleum Industry Research Foundation says, "The most visible effect so far is the sea change in operational procedures, safety provisions, and inspection routines now being implemented in the oil trades."

Safety of Life at Sea (SOLAS), Consolidated edition. (1992).

This publication contains a consolidated text of SOLAS 1974, SOLAS Protocol 1978, and all subsequent amendments up to and including 1990 amendments. The text has been compiled by the secretariat at the direction of the Council and is intended to provide an easy reference to all SOLAS requirements applicable from 1 February 1992.

International Maritime Organization. Code on Alarms and Indicators. (1992).

The Code on Alarms and Indicators was developed in accordance with a decision taken by the Maritime Safety Committee (MSC) at its forty-eighth session and adopted by the Assembly at its seventeenth session (November 1991) by resolution A.686(17). Designed originally to cover the alarm an dindicator provisions in chapters II-1 and II-2 of the International Convention for the Safety of Life at Sea, 1974 (1974 SOLAS Convention), the Code, in the course of its development, has incorporated the relevant provisions of other SOLAS chapters as well as thise of associated codes (IBC and IGC COdes) and also of the codes for existing ships (BCH and Gas Carrier Codes)

International Maritime Organization. GMDSS Operating Guidance for Masters of Ships in Distress Situations. (1992).

Poster of flowchart of decision making process for distress situations

Flyntz, F. J. Naval War Coll., Newport, RI. Manning the Ready Reserve Force (Final report). (1992).

Sealift is needed for National Defense. The best source of sealift is a healthy Merchant Marine. The U.S. Merchant Marine is in a serious downward spiral, to make up for the lack of available commercial ships in the RRF (a subset of the NDRF) was created. These ships are laid up in increased states of readiness and are dependent on the existing pool of available merchant mariners for manning. Unfortunately as the Merchant Fleet declines mariners available to man the RRF also dwindles, until now there is serious doubt that there are sufficient mariners available to provide crews for the RRF. Numerous studies of this problem have been based on statistics, exercises and speculation. The activation of the RRF for Desert Shield/Desert Storm involved 80% of the ships and was the only real exercise of the RRF to date. Lessons learned from Desert Shield/Desert Storm bear on the validity of the previous studies and the conclusions drawn. This paper will consider only the issue of manning for the RRF in it's present and planned size. The research involve published and unpublished documents relating to the RRF and information gleaned from government databases available to the author. The chief findings of the study are that a quantitative and qualitative manning problem exists and is becoming worse. The problem is greatly exacerbated by present procedures for distributing the manpower. Solutions have been proposed to increase available manpower. These include a civilian reserve program, Navy Reserve manning and programs to enhance the present system.

ISO. Resolution A.78(17) Navigation Bridge Visibility and Functions. (November 1991).

Annex contains "Guidelines on Navigation Bridge Visibility"

Phillips, Francis . "Larsen's Future-ship" from Containerisation International, p. 43-44. (November 1991).

Background/history of Knud I. Larsen Shipping co. (KIL)

Ships can operate safely with an 8-man crew (Captain, 2 mates, 2 engineers, 3 ratings) and can carry up to 1K TEU of cargo. Has a satellite-derived positioning data, computerized chart screen plot. Pre-drawn track can be followed on "auto."

Crew gets 2 months of intensive training in all shipboard systems.

Designed as part of the Danish "Ship of the Future" project.

Ships have begun operating with 10 or 11 man crews. Soon radio operators will no longer be necessary, and only practical considerations (e.g. trainees, mates to keep watches less than 12 hrs) will keep numbers above 6. 9 is seen as real minimum (8 mentioned above + a cook).

Douglas, Carl and Meyers, Christina - Presearch Inc. for USDOT. Crewing the Merchant Marine for Mobilization. (January 1991).

Abstract: The purpose of this study is to determine methods of achieving adequate manning of merchant vessels for national security needs during a mobilization. Previous merchant marine manning studies and the efforts of working groups trying to solve the seafarer shortage problem are reviewed. Seafarer availability is compared against mobilization requirements for the years 1990, 1995, and 2000 to determine manpower shortages. The general nature of the U.S. maritime problem is reviewed with a recognition of the different requirements for short-term (surge phase) and long term (sustainment phase) mobilization scenarios. Mobilization manning solutions that reduce mariner requirements are developed. These include reduced Ready Reserve Force (RRF) manning, RRF caretaker crews, U.S. Naval Reserve manning, and the change of government regulations made with shipping company and union cooperation. Various solutions to increase seafarer availability are determined. Four different U.S. Maritime Service Reserve alternatives are developed. The conversion of domestic waterways, general industrial, and former military/maritime personnel to the oceangoing profession is investigated. Accelerated training of maritime school personnel and a mariner tracking system are examined. Other miscellaneous methods of increasing seafarer availability that include changing government regulations, instituting a merchant marine draft, and providing the Maritime Administration the authority to crew priority vessels are developed.

Marine Institute of Technology and Graduate Studies. MITAGS Bridge Team Management Course. (1991).

Themes: Breaking the error-chain and responding to the unexpected using bridge simulators to recreate underway bridge operations. Emphasis on proper pre-passage planning, efficient ship handling, model bridge team organizations and procedures, and crisis management.

Kreuger, G.P. "Sustained Military Performance in Continuous Operations: Combat Fatigue, Rest and Sleep Needs" from Handbook of Military Psychology. (1991).

Personnel who work during night and sleep during day get only brief fragmented sleep and often accompany significant sleep debt. Combination of Sustained Performance and sleep deprivation have implications for theoretical models of sustained perception and cognitive functions.

Pell (102nd Session of Congress). Convention on Standards of Training, Certification, and Watchkeeping for Seafarers. (1991).

Abstract: The Convention will establish standards of training, certification and watchkeeping for seafarers. It is intended to ensure more highly qualified personnel on board "seagoing" merchant ships and thus reduce maritime casualties and promote safety of life at sea and protection of the marine environment.

Resolved, that the Senate advise and consent to the ratification of the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers with Annex, 1978 done at London, July 7, 1978.

Cabon, Ph., Mollard, R., and Coblentz, A. "Sleep Deprivations and Irregular Work Schedules" from Proceedings of the Human Factors and Ergonomics Society 35th Annual Meeting. (1991).

Focused on sleep deprivations for 1) aircrews during long-haul routes and 2) drivers for ground transport (Train)

Results: Strong reduction of sleep duration during day-time rests for ground transportation drivers. Results confirm that sleep duration is determined by rest starting time. Sleep periods during day-rests are organized into naps and sleep. For air crews, North-South Travel has normal sleep durations. East-West travel has a rebound effect of sleep deprivation and poor sleep quality was noted.

Feyer, A., and Williamson, A.M.. "The Role of Work Practices in Occupational Accidents" from Proceedings of the Human Factors and Ergonomics Society 35th Annual Meeting. (1991).

Comprehensive classification system applied to analysis of information surrounding the occurrence of all traumatic work-related fatalities from 1982-1984.

Information included factors immediately before as well as factors removed in time which contributed to the accident.

Results: Relationship between human and other factors, among human factors and between factors immediately before and factors removed in time all contributed to accidents. Poor work practices accounted for 45% of accidents, and of that percentage, 80% were classified as the root cause of the accident.

Warm, J.S., Dember, W.N., Gluckman,J.P., and Hancock, P.A.. "Vigilance and Workload" from Proceedings of the Human Factors and Ergonomics Society 35th Annual Meeting. (1991).

Focus on overall workload inherent in vigilance tasks and possible effects on vigilance performance of workload transitions

Subjects shifted from low to high event rate performance more poorly than controls maintenance on a high event rate

Subjects shifted from single task to dual task monitoring performed at the same level in the dual as subjects who were confronted with dual tasks throughout

Depending on how the change in workload is achieved, performance deficits can be observed when subjects are shifted from low to high and high to low workloads

"Shipbuilders Hope Crewless Cargo Ships are Wave of Future" from Journal of Commerce, p. 1b. (1991).

Within a few years, ships may be unmanned, escorted by 1 crewed mother vessel, controlled by autopilots getting instructions from Satellite Navigation, according to Roland Burns at Polytechnic South West (Plymouth, UK). Reduction of human error would improve safety at sea. reduced running costs would offset the added costs of building computer-controlled vessels in a few years.

Hura, Myron & Robinson, Richard. Fast Sealift and Maritime Prepositioning Options for Improving Sealift Capabilities. (1991).

Until recently, the privately owned U.S. flag merchant fleet provided sufficient numbers of dry cargo ships to transport military unit equipment (u/e). In the past decade, however, the number of dry cargo ships in this fleet decreased by approximately one third, from more than 300 to about 200. Equally important, the direct military utility of this fleet decreased substantially because of the increased proportion of container ships. Today, the fleet included about 94 pure container ships, which without special cargo modules cannot carry the vast majority of Army u/e. If these trends continue, DOD will no longer be able to simply requisition a large number of privately owned U.S. flag ships and employ them without modification to deliver u/e.

This Note, which is the result of research conducted between January 1988 and March 1990, addresses two questions: (1) To what extent can future U.S. flag merchant ships and existing government sealift programs support potential force deployment requirements? (2) If fast sealift ships (FSSs) and maritime prepositioning ships (MPSs) for Army equipment are needed, what kinds of ships should be built and in what operating regime should they be maintained?

Landsburg, A., Grabler, E., Levine G., Sonneschein, R., and Simmons, E.. "US Commercial Ships for Tomorrow" from Marine Technology 27,3 pp.129-152. (May 1990).

Abstract: Foreign "ship of the future" research programs, recent design work and other studies are in the background for this paper, which addresses the interaction between innovation and competitiveness; trends in economics, advances in technology; effective manning; social needs; and design constraints. The paper then provides a discussion of attractive innovations and avenues toward U.S. competitiveness in the maritime industries of tomorrow."

Society of Naval Architects and Marine Engineers for USDOT - Maritime Administration. Ship of the Future 2000 - Workshop Proceedings. (May 1990).

These Proceedings contain summaries of presentations made at the Ship of the Future - 2000 Conference. The full presentations were edited and shortened. It is hoped the Proceedings accurately depict that which the presenter intended. If not, this is regretted and corrections are welcomed. The Concept Designs depicted herein are also very brief summaries of the actual designs prepared. If copies of the full presentations, or Concept Designs, or additional information in the various subjects is desired, it is believed the presenter or designer will be happy to furnish this information on request

Segal, L.D., and Wickens, C.D.. "Taskillan II: Pilot Strategies for Workload Management" from Proceedings of the Human Factors and Ergonomics Society 34th Annual Meeting. (1990).

Focused on strategies used by pilots in managing workload level and subsequent task performance. Results suggest that intelligence supported strategies that yielded significantly higher performance levels, while schedule control had no impact on performance. Both difficulty type and the stage of difficulty impacted performance significantly with strongest effects for time and stress and difficulties imposed late in the flight.

National Transportation Safety Board. Marine Accident Report - Grounding of the U.S. Tankship EXXON VALDEZ on Bligh Reef. (1990).

Abstract: This report explains the grounding of the US Tankship EXXON VALDEZ near Valdez, Alaska, on March 24, 1989. The safety issues discussed in the report are the vessel's navigation watch, the role of human factors, manning standards, the company's drug/alcohol testing and rehabilitation program, drug/alcohol testing, vessel traffic service, and oil spill response. Safety recommendations addressing these issues were made to the US Coast Guard, the US Environmental Protection Agency, the US Geological Survey, the Exxon Shipping Company and other tankship companies carrying North Slope crude oil from Port Valdez, the State of Alaska, the Alyeska Pipeline Service Company and the Alaska Regional Response Team.

NAVPERS. Navy Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards -- Section II NEC's. (1990).

Abstract: The Navy Enlisted Classification (NEC) structure, of which the NEC coding system is a part, supplements the enlisted rating structure in identifying personnel on active or inactive duty and billets in manpower authorizations. NEC codes identify a non-rating wide skill/knowledge/aptitude/qualification that must be documented to identify both people and billets for management purposes. The NEC coding system facilitates management control over enlisted skills by identifying billets and personnel and enhancing efficient utilization of personnel in distribution and detailing. In cases where NECs reflect special training, inventories of coded billets and coded personnel are also the basis for planning and controlling input of personnel into formal courses that earn NECs. Consequently, the continuing enlisted strength of the Navy, particularly petty officer allocations, and funds authorized for rating and specialty training depend, to an increasing extent, upon the accuracy, thoroughness, and timeliness of NEC coding. Personnel required to support ratings and special programs must be identified by the correct combinations of rates and/or NECs.

Comperatore, C.A., and Kreuger, G.P.. "Circadian Rhythm, Desynchronosis, Jet Lag, Shift Lag, and Coping Strategies" from Occupational Medicine: State of the Art Reviews, 5(2) 323-341. (1990).

Circadian Timing System (CTS) synchronizes physiological and behavioral rhythms to a Circadian cycle and can be reset by the influence of the Environmental Light-Dark (LD) cycle

Jet Lag/Shift Lag - results from desynchronosis, adversely affects worker performance and health because shift workers' rhythms of body temperatures and sleep do not completely reverse to match their duty schedules

Effects of Jet Lag on Performance - psychomotor performance after a 6h transmeridian flight suffers a reduction of 8-10% of preflight levels (Comparable to that observed when BAC is .05%)

Shiftwork and Shift Lag - different from jet lag in that workers' schedules conflict with sunrise/sunset and social schedules of families. Traditional shiftwork fails to account for many Circadian rhythms variables

Pollard, J.K, Sussman, E.D., and Stearns, M.. Shipboard Crew Fatigue, Safety, and Reduced Manning. (1990).

Abstract: This report describes an exploratory first phase of an investigation of human stress and fatigue in the merchant marine. Its principal purposes were to: survey the effects of fatigue on human performance in the transportation industries; describe the state of the art in measuring fatigue; investigate the causes of stress and fatigue on merchant ships; summarize the insights gained about the implications of reduced manning as well as measures to mitigate fatigue; and discuss the results of preliminary attempts to gauge fatigue during the routing voyages using survey methods. The findings in this report are based primarily upon about three dozen extended interviews conducted with officers on five merchant vessels during brief coastal voyages. In the course of these interviews, more than a score of variables were identified which affect fatigue and stress, which may be grouped into organizational factors, voyage and scheduling factors, ship-design factors, and physical/environmental factors. These interact in complex fashion resulting in widely different levels of fatigue on different ships and in different situations. The physiological and behavioral methods of fatigue measurement reviewed were found to be difficult to apply during routine operations, but the self-reporting survey techniques tested eventually proved quite workable. It was concluded that organization and design factors could provide opportunities under some circumstances for the design of advanced merchant ships which can be sailed safely and efficiently be well-rested crews which are smaller than are common today.

Stoop, J. "Redesign of Bridge Layout and Equipment for Fishing Vessels" from Journal of Navigation, 43: 215-228. (1990).

Abstract: The safety on board medium-sized fishing vessels in relation to working conditions on the bridge is analyzed by means of a problem-solving method developed by the Safety Science Group of the Delft University of Technology. The potential of the method is illustrated by a number of case studies on selected aspects of the bridge design, since a complete application of the method is not yet available. For an in-depth analysis of human error, a cognitive model of human error theory is extended to a new application to give a prospective evaluation of risk in operator tasks. Accident data, findings of a questionnaire and verdicts of the Dutch Shipping Council are used to formulate a topology of accidents and of specific use conditions, resulting in descriptive accident scenarios. Priority accident scenarios are defined, within which mental workload and human error are selected for an in-depth analysis as two main contributing factors to accidents. From the full range of potential social, organizational and technical solutions, redesign of the bridge layout and equipment is selected as an example of further development to improve the working conditions on the bridge. The classification of accidents and the identification of specific use conditions enable us to formulate retrospective design requirements for specific sub-problems. The application of a cognitive model of human error to a normative task description enables us to formulate prospective design demands for the bridge tasks, layout and equipment. As a precursor to an extensive study of the bridge and equipment redesign of a fishing vessel, results are shown of two pilot studies: the design requirements for the navigation task and the introduction of a new solution, the low-cost ARPA.

National Research Council. Crew Size and Maritime Safety. 1990.

Abstract: The committee's study encompassed all aspects of the safety issues raised by smaller crews. It was charged with: identifying the economic and technology changes that are causing manning reductions; forecasting the evolution of ship operating technology and the associated changes in crew organization and training; identifying the risks of smaller crews and assessing how they may be affected by changes in manning patterns; assessing the implications of smaller crews for training, skill levels, crewing patterns, and vessel operating technology; and developing a method for assessing the effects on safety of crew size, organization, and capabilities.

"Safety: Long Working Hours Are Reducing Safety Standards" from Safety at Sea. (1990).

Report on a voyage from Immingham to Gdynia in Poland via Hamburg in January 1988. Personal testimony from R. Potts, Master of a bulk Carrier. Worked 88 hours in stressful conditions without sleep.

Reduced manning contributes to less sleep for crew, less social interaction with crew, less ability to go ashore.

Legislation sought to ensure that officers are relieved at short intervals.

Too much money put into construction of ships, not prevention of collisions, etc.

Problems with cut sick pay. (crew members who should be on sick leave refuse it for fear of losing their job completely). Same concerns for pilots.

Reduced manning has made longer hours the norm, not the exception.

"Fatigue and Its effect on Safety" from Safety at Sea. 1990.

Report from Cpt. David Bland relating to work on offshore supply vessels. Blames systems for governing number of hours a truck driver can drive, etc., and the same system which says you will come on and work until the job is complete or you fall over from fatigue. Asks for cooperation and communication.

101st Congress. Oil Pollution Act of 1990 (PL 101-380). 1990.

Abstract: An act to establish limitations on liability for damages resulting from oil pollution, to establish a fund for the payment of compensation for such damages, and for other purposes.

Maritime Institute of Technological and Graduate Studies. Electrical and Integrated Navigation Systems -- 1 Week Course outline. (1990).

Familiarized students with integrated navigation steering systems using the JRC-Raytheon SNA-91 computer system. Sperry SRP-2000 and Laser Plot's Chart Nav. 20/20 electric navigation devices provide input to the navigation console which also monitors and steers the vessel.

All components of integrated navigation systems are examined, including the chart digitizer and navigation console. Electronic navigation and weather routing will also be covered.

ISO. "Ship's Bridge Layout and Associated Equipment -- Requirements and Guidelines" ISO 8468. (1990).

This International Standard specifies basic functional requirements for bridge configuration, bridge arrangement, bridge equipment, and bridge environment. It has been developed to ensure that designs of ship's bridges provide adequately for the requirements for safe navigation to prevent confusion arising from bridge arrangements which are unusual.

Koburger, C.W.. "EXXON VALDEZ - End of an Era?" from Sea Technology. (1989).

Description of accident and ensuing damage, and damage containment procedures

Errors that occurred after the spill by management organizations; not just CG errors

CG VTS not utilized -- too few people to serve adequate protection and service to VALDEZ. Calls for CG to take a more active aggressive role as policemen in the future.

Kreuger, G.P.. "Sustained Work, Fatigue, Sleep Loss, and Performance: A Review of the Issues" from Work and Stress 3(2) 129-141. (1989).

Abstract: The physiological and psychological stressors associated with sustained work, fatigue, and sleep loss affect worker performance. This review describes findings relating to sustained work stresses commonly found in our advancing technological world. Researchers report decrements in sustained performance as a function of fatigue, especially during and following one or more nights of complete sleep loss, or longer periods of reduced or fragmented sleep. Sleep loss appears to result in reduced reaction time, decreased vigilance, perceptual and cognitive distortions, and changes in affect. Sleep loss and workload interact with circadian rhythms in producing their effects. These interactions are a major source of stress in work situations requiring sustained work in continuous operations and have implications for theoretical models of sustained perceptual and cognitive functioning.

Schuffel, H., Boer, J.P.A, van Breda, L. "The Ship's Wheelhouse of the Nineties: The Navigation Performance and Mental Workload of the Officer of the Watch" from Journal of Navigation, 42:60-72. (1989).

Abstract: The search for more efficient ship operation has increased over the last decade. One trend towards reducing operational costs is to conceive the wheelhouse as an operational center for performing both navigational and supervisory tasks, such as monitoring the propulsion plant status and the condition of ship and cargo. Under contract to the National Foundation for the Coordination of Maritime Research in the Netherlands, a study was conducted on the feasibility of a highly automated wheelhouse for single-handed navigation. In a series of simulation experiments, and by analysis, the effects on efficiency and safety of performance were investigated. Results show that a careful function allocation can lead to an automated wheelhouse concept suitable for safe navigation in landfall conditions. Questions concerning the effects of monotonous watches on operator's alertness and the effects of the change in task structure on the operator's skill and interest in the job need further attention.

Larsen, F.S. "Danish Ship of the Future" Extracts from a paper by F.S. Larsen. Naval Architect, p. E172-173. (May 1988).

Due to decreasing numbers of small ship companies in Denmark, a new manning law was set in, and a technical program to develop a high tech ship for small owners was started by the Danish government. The Objectives of the technical program:

1. Design a vessel within 12 months of 5K-7K dwt
2. 6 man safe manning certificate approved by authorities
3. Good future market possibilities
4. Full building specifications
5. Class-approved drawings
6. A design fulfilling national and international requirements

"APL's President Truman - First C10" from Marine Log pp.52-56.. (June 1988).

APL's attempt to cut shipping costs to $.05 per box per mile -- Has a "Panama Canal busting beam of 129 ft, 3in" and a service speed of 24 knots. Container capacity of 4,300 TEU, with 20ft, 40ft, 45ft, and 48ft units. Containers are secured to lashing bridges (not hatch covers), reducing manpower requirements in port. Has 440V connections for refrigeration containers.

Efficiency due in part to less need for ballast (5%) due to the wider beam. Has the largest diesel engines built (Sulzer 12RTA84). "C10s meet American Bureau of Shipping ACCU notation with a Siemens Simos/Sigos/Simatic automatic installation monitoring unattended machinery spaces and controlling pumps and valves." Computer controlled maintenance and regulation of engine performance.

All navigation functions can be carried out from the wheelhouse. Bridge contains digital seacharts with data exchanges between the chart and the radar. "If the U.S. Coast Guard rules were relaxed, bridge operations could be handled by one person" Theoretically the C10 could operate with only 12, but under present regulations, it operates with 9 officers and 12 crew (still a low number). (Personnel have individual cabins; accommodation for an additional 12 is also provided, as well as a gym, bars, sauna, swimming pool, and a visitor reception area.)

"APL's C10 Container liners: A New High Speed Trans-Pacific Link" Naval Architect. (July/Aug 1988).

APLs five 54,500dwt superships - designed expressly for Pacific routes- are the first container carriers anywhere to exceed Panama beam and are fitted with the largest diesel engines ever built.

The ship needs less ballast and can stack more efficiently than Panama class because of the 39.4 meter beam, and is faster (24 knots service speed).

Maintenance would be carried out by shore gangs, but careful attention has been paid to machine access. 2 A/C workshops on board, one mechanical, one electrical, with fuel valve test facilities.

Super automated - Centralised Alarm Monitoring and Control Concept (CAMAC) - relies on a high degree of redundancy and automatic changeover on failure to endure continued efficiency throughout a voyage.

Have 8 CRTs (3 in engine control room, 2 in wheelhouse, 1 in deck office, 1 in chief engineer's office, 1 at main emergency control station). Also has a "ship of the future" bridge design.

Expects a 41% capacity increase by 1989.

ASTM. Standard Practice for Human Factors Design for Marine Systems, Equipment, and Facilities. (1988).

Abstract: The purpose of this practice is to present human engineering design criteria, principles, and practices in order to achieve mission success through integration of the human into the vessel system, subsystem, and equipment with the goals of effectiveness, simplicity, efficiency, reliability, and safety for operation, training and maintenance.

Hadley, M.A.. "Present Trends in Naval Bridge Design and Integrated Navigation" from Journal of Navigation, 41(2) 276-287. (1988).

Abstract: Although the Royal Navy has used various bridge designs during the past 20 years it has chosen a readily recognizable layout for its Type 23 frigate. This conservatism is not the result of a willful disregard for changes being made elsewhere in the marine world but arises from the particular requirements of a warship's bridge and considerable differences in manning. The most significant changes to layout, in recent years, have been the siting of the quartermaster on the bridge, the introduction of the versatile console system (VCS) of instrument display, the provision of engine controls at the quartermaster's console and the siting of a radar display at the bridge front. The need for, and availability of, greater navigational accuracy, plus the requirements of the command system, has caused a fresh look to be taken at the handling of navigation data. This re-evaluation, which is still at an early stage, is not only examining the processing but also the display of data; this latter aspect could have an impact on future bridge design. The remarks in this paper are made with respect to a frigate size ship or above and the terms warship and naval vessel refer specifically to those of the Royal Navy.

Landsburg, Alexander C., Historic Overview of Manning and Habitability. (November1987).

One graph - Seafaring Employment from 1925 to 1975 from Naval Engineers Journal, December 1976.

Two tables: Crew complement for typical U.S Merchant vessels and Typical Manning Scales

American Bureau of Shipping Research & Development Division. Ship of the Future: Competitive Manning. Preliminary Literature Review. (January 1987).

The following is a preliminary review of relevant literature to ships of the future with emphasis on manning aspects. Because of time constraints the primary source of this material was the literature search performed by the National Maritime Research Center (NMRC) using the MARIBASE online database. Information was also found through preliminary review of ABS sources.

Ship Analytics for USDOT MARAD. Shipboard Productivity Methods Final Report Vol.1 Project Summary Report No. MA-RD-770-87002. (February 1987) .

Abstract: This research project, under a cooperative agreement between the Maritime Administration and Pacific Gulf Marine, investigated means to advance the productivity of merchant ships through organizational, procedural and manpower improvements in the ship-shore work system. The project was used as a vehicle to develop and apply systematic organizational and work assessment techniques on order to identify features of the total ship-shore work systems which, if altered on a trial basis, would demonstrate potential benefits of increased efficiency and effectiveness in ship operation. Changes involved ship and shore policy and procedures, shore services, the organization and distribution of functional duties among personnel and their associated training requirements, and the provisions for new equipment and materials on board and ashore. Trial changes were selected and implemented in cooperation with labor unions and the U.S. Coast Guard. The trials were monitored, and observational results compared to the original work system assessment in order to objectify change effects. A follow-on project is a recommended to permit long-term change to be undertaken and will also afford the opportunity to determine the persistence of initial change effects. Results from the study include the specification of an objective method for planning and executing directed change efforts which can be generalized to other merchant marine fleets.

Ship Analytics for USDOT MARAD. Shipboard Productivity Methods Final Report Vol.2 Shipboard Management Workshop Manual Report No. MA-RD-770-87003. (February 1987).

Workshop Overview: The first purpose of this workshop is to initiate your involvement in the planning and development of an enhanced ship-shore organization and management structure. The main objectives of formalizing or restructuring the shipboard organization are 1) to optimize the utilization of the ship and company resources including crew skills and manhours, and 2) to achieve a more autonomous and responsible corporate unit.

Objectives: To gain Masters' and Chief Engineers' participation as the primary facilitators of a shipboard management enhancement program. As such, the Masters and Chief Engineers will, as a team, identify, formalize, and implement changes to the shipboard management and ship-shore interface structure.

End Products: The end product of the workshop will be a detailed plan for a formal management program to be implemented on board your ship. The plan will identify specific developmental projects which can be undertaken immediately aboard a PGM ship. Formalization of the shipboard management structure will be supported by aids such as charts, job descriptions, performance appraisal systems, etc., to be specified during the workshop. Enhanced management procedures will be implemented on board the ship by the Master and the Chief Engineer with the full support of PGM management and Ship Analytics.

U.S. Department of Transportation. Shipboard Productivity Methods, Vol 1: Project Summary. (February1987)

Abstract: In three volumes this research project, under a cooperative agreement between the Maritime Administration and Pacific Gulf Marine, investigated means to advance the productivity of merchant ships through organizational, procedural and manpower improvements in the ship-shore work system. The project was used as a vehicle to develop and apply systematic organizational and work assessment techniques in order to identify features of the total ship-shore work system, which, if altered on a trial basis, would demonstrate potential benefits of increased efficiency and effectiveness in ship operation. Changes involved ship and shore policy and procedures, shore services, the organization and distribution of functional duties among personnel and their associated training requirements, and the provisions for new equipment and materials on board and ashore. Trial changes were selected and implemented in cooperation with labor unions and the US Coast Guard. The trials were monitored, and observational results compared to the original work system assessment in order to objectify change effects. A follow-on project is recommended to permit long-term change to be undertaken and will also afford the opportunity to determine the persistence of initial change effects. Results from the study include the specification of an objective method for planning and executing directed change efforts which can be generalized to other merchant marine fleets.

Donn, Clifford B. . "Federal Subsidies, Technological Change and Collective Bargaining: The Maritime Industry" (abstract) from Atlantic Economic Journal 15(1):115). (1987).

Abstract: There has been a dramatic decline in the size of the US Flag ocean-going merchant fleet since WWII and the decline has accelerated in the last decade. This has occurred in spite of intensive direct and indirect government subsidies to maintain merchant marines as a viable military adjunct in case of a national emergency. Recent technological change has resulted in decreased employment. These 2 factors and recession have produced a substantial bargaining concessions by the unions in he industry. However, it seems only substantial public policy changes have the potential to reverse the industry's decline.

Knudsen, R. K., Mathiesen, T.C. . "Operational safety and Minimum Manning" from the Society of Naval Architects and Marine Engineers No. 27. (1987).

Abstract: a classification society would fail its purpose if it turned its back on the development towards lower manning levels. Safety aspects of reduced manning are discussed. An investigation into the safety aspects of new maintenance strategies are reported, together with requirements to technical systems, to logistic arrangements and to operational restrictions. A method for evaluating manpower requirements and determining minimum and optimum manning is illustrated. Det Norske Veritas has developed a framework for operational class notations. Existing class notations and development plans are described. Ship operation centre on bridge and on-man-operation are dominant development trends. Nautical safety may become even more important than before. Class notations for nautical safety and for one-man-operation are described.

Low, A. , Goethe, W. , Rutenfranz, J., Colquhoun, W.P. , et al.. "Human Factors: Effects of Watchkeeping -- Results of Studies for a German Ship of the Future" from the Society of Naval Architects and Marine Engineers No. 11. (1987).

Abstract: A brief review of the development of watchkeeping systems on ships from ancient times to the present is given. The results of an international inquiry as to prevailing watch systems in 30 countries as well as those from a national survey in the German merchant fleet are described. Data from a 2 year study of psychophysical workload among watchkeeping officers on 10 fast ships on NSN and WEW routes is presented and discussed in connection with adaptation to eventually occurring time shifts. Practical consequences and alternative watch schemes are suggested to improve vigilance and performance. The authors conclude with future outlooks - from the physician's viewpoint - in modern shipping with its declining crew sizes and large scale competition as to reducing stress for the watchkeeper.

Harding, E.J. . "The Ship of Things to Come" . (October 1986) .

The application of advanced technology and operating techniques to commercial shipping has been recognized as critical to future competitiveness. Several countries have funded their own research programs also have distinctively different characters and directions.

Mangier, Mark . "Six-Man Ship Crew Wave of the Future?" from the Journal of Commerce. (October 1986).

Small tankers, bulk vessels and containerships could operate with a crew of six within three years, according to a plan outlined by Det Norske Veritas, the Norwegian ship classification society

National Transportation Safety Board. Marine Accident / Incident Summary Reports - Mississippi River Gulf Outlet Canal (AM HOWARD). (1986).

The Accident - lift boat with only port engines working grounded on rocks in high winds/hurricane and sank

Rescue Operations - USCG and RIP TIDE (3 AM HOWARD crew died)

Damage to Vessel - grounding caused fractures

Vessel Information - not classified by ABS, nor CG

Crew information - no licensing requirements, no licensing for master (unrenewed), no drills

Lift Boat Operations - unknown restriction of cargo, no documentation on board, no anchor or high water alarm, no pump, void not subdivided --other similar accidents for lift boats had been reported

Probable Cause - master's decision to depart Hopedale in adverse weather conditions - Contributing was lack of subdivision in hull, and lack of training & guidance.

United States General Accounting Office. Navy Sealift: Observations on the Navy's Ready Ready Reserve Force, Appendix I: Report to the Assistant Secretary of the Navy. (1986).

In October 1976, we reported that the national Defense Reserve Fleet (NDRF) could not be activated within the 10- to 15-day period DOD required at that time. The RRF -a quick response sealift component of the NDRF- was subsequently established as a joint program of MARAD and the Navy to provide cargo ships for use in a contingency

within 5 to 10 days of notification. These Navy-owned ships will be activated by commercial companies, using private shipyards or repair facilities, and will be crewed by civilian merchant marine personnel hired from union rosters. As of January 1986, the RRF consisted of 72 ships; current DOD planning calls for expansion to 136 ships (100 cargo ships and 36 tankers) by fiscal year 1992.

International Maritime Organization. International Conference on Revision of the International Regulations for Preventing Collisions at Sea, 1972. 1985, 1990. Final Act of the Conference,

Attachment 1 - Including the Convention on the International Regulations for Preventing Collisions at Sea, 1972

Part A - General

Part B - Steering and sailing rules

Part C - Lights and shapes

Part D - Sound and light signals

Part E - Exemptions

Annex I - Positioning and technical details of lights and shapes

Annex II - Additional signals for fishing vessels fishing in close proximity

Annex III Technical details of sound signal appliances

Annex IV - Distress signals

Attachment 2 - Resolution I

Attachment 3 - Resolution II

Colquhoun, W.P.. "Hours of Work at Sea: Watchkeeping schedules, Circadian rhythms and Efficiency" from Ergonomics 28(4) 637-653.. (1985).

This review is concerned with hours of work of personnel engaged in watchkeeping. Existing findings are considered in the context if the degree of adjustments shown by physiological and performance rhythms to various watchkeeping systems in use on different ships. Findings are discussed in relation to a proposed program of research aimed at determining the optimal system for maintaining efficiency of crew operating the modern, fully automated ships.

Committee on Effective Manning- Commission on Engineering And Technical Systems- National Research Council. Effective Manning of the US Merchant Fleet . (1984).

Scope of Study: The charge to the committee was to provide a technical background and analysis in support of management, labor, and government decision making regarding the means and process by which effective manning may be best accomplished in the U.S. flag merchant fleet. The committee assessed the experiences of other countries with manning innovations, the similarities and differences between the United States and other countries in the conditions and factors important to implementing such changes, and the considerations important in making decisions about effective manning of the U.S. flag fleet. Among the factors considered were the safety and efficiency of vessels, and opportunities presented by new technology, management of change, and organization of crews. The committee directed its assessment to providing a basis for decisions and policy. It did not formulate a plan of action or select from candidate alternatives for manning. The committee's interest extended beyond manning innovations to their impacts on safe and economic operation, and to the mitigation of side effects such as unemployment, altered career paths, and changes in the nature of shipboard work and quality of shipboard life.

Benford, Harry . Ship manning trends in northern Europe : Implications for American shipowners and naval architects. In: Transactions, The Society of Naval Architects and Marine Engineers. v. 92 p. 303-329: ill.. (1984).

Abstract: In this paper you will find a summary of the interwoven economic, technical and social factors that are forcing changge in the management of merchant fleets of northern Europe. The cumulative effect upon seafaring life, seafaring careers, and the ships themselves has been pronounced. Human factors have in the past been relatively neglected in comparison to the attention given to technical and economic factors. If the fleets of high-wage nations such as the United states are to survive in international competition, ways must be found to increase the productivit of crew members to a level commensurate with their earnings. This can be achieved only through a strategy of designand operation that intertwines social, economic and technical considerations into an integrated unity. This is my primary conclusion. From it follow important implications for fleet managers, seafarers, ship designers, and the appropriate centers of education and training. Despite differences between European and American environments, some -- perhaps most -- of what has been learned abroad can be applied over here. These lessons may, indeed, offer promise of overcoming the handicap of high wage rates in the U.S.-flag merchant fleet.

Perrow. The Organizational Context of Human Factors Engineering. (1983).

Explains why top management personnel are indifferent to good HF design and shows how the social structure favors the choice of technologies that centralize authority and deskill operators and how it encourages unwarranted attributions of operator error.

Hagen, ed.. Control and Instrumentation. (1982).

Produces a practical method for actually determining the opportunities for human errors with safety systems - until further validations exists use caution when using these results outside the context of this study

- initial quantification of error by applying a model of the number of human errors divided by the opportunities for the specific errors associated with the operation, maintenance, and testing of instruments and controls (I&C) components in nuclear power plants
- Work has resulted in the development of a specific set of human-error-rate(HER) categories covering above errors.
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US Coast Guard. Boat Crew Qualifications and Certification Manual Vol. I Crewmembers (COMDTINST M16114.6). (1982).

Abstract: This publication establishes a standard boat crew qualification and certification manual that will provide 1) a servicewide minimum standard basic training program for SAR boat crews and 2) servicewide minimum requirements for qualification and certification.

Vol. I Crewmembers

Vol. II Coxswains

Vol. III Advanced Coxswains

Vol. IV Boat Engineers

Lists 121 Tasks that are minimum requirements for boat crewmembers.

International Maritime Organization. Noise Levels on Board Ships. (1982).

The Code on Noise Levels on Board Ship has been developed to provide guidance to Administrations on proncibles of noise control on board ships in general. Its purpose is to stimulate and promote noise control at a national level within the framework of internationally agreed guidelines.

NTSB. Special Study- Major Marine Collisions and Effects of Preventative Recommendations.. (September1981)

Abstract: From 1970 through 1980, the National Transportation Safety Board investigated 82 major marine accidents. Thirty-three (40 percent) of these were collision accidents. The Safety Board initiated this study to examine a representative segment of ship collision investigation data based on the Safety Board's marine investigation experience. The study identifies some leading causes of ship collisions and assesses the results of the Safety Board's collision prevention recommendations made to Federal agencies and to maritime organizations. The study found that human error is the predominant cause of ship collisions and that specialized marine accident data which underscore the human factor in the cause of ship collisions need to be collected. Many of the Safety Board's past recommendations aimed at improving steering gear reliability will be resolved as the Coast Guard implements U.S. steering gear regulations in consonance with the current IMCO revisions to the 1974 SOLAS Convention. The Inland Navigational Rules Act of

1980 is responsive to many of the Safety Board's recommendations to upgrade navigation rules. The study recommends additional measures to increase the effectiveness of the ship's bridge watch team, and the collection of data concerning the human factors that contribute to the cause of ship collisions.

Office of Naval Technology. Research Needs to Reduce Maritime Collisions, Rammings and Grounding.. (May 1981) .

Abstract: This report contains an evaluation of the research needed to prevent marine casualties --specifically collisions, rammings, and groundings-- associated with vessel controllability. A review of existing studies and casualty data, combined with the committee's experience, resulted in the identification of four major categories of marine-casualty factors: personnel; ports and waterways, aids to navigation; and vessel characteristics, maneuverability, and hydrodynamics. A significant amount of research on systems, hardware, and human behavior exists that is applicable to these categories. However, there are important gaps in basic hydrodynamic research. The committee further determined that a basic problem in the maritime industry is not so much the lack of research, but a need to disseminate information, coupled with coordination of research and a serious effort to apply existing knowledge.

Essex Corporation, T.B. Malone, C. Baker, W.T. Kosmela. Human Factors Technology for Ships. (January 1981).

The United States Navy is currently involved with designing and procuring an electro-optcal fire control subsystem, know [sic] as SEAFIRE, to be integrated with existing shipboard Gunfire Control Systems (GFCS), the Mk 86, Mk 68, and Mk 92.

A requirement that has been imposed on the SEAFIRE design is that no additional manning shall be required to operate or maintain the integrated SEAFIRE system above current GFCS levels.

The purpose of this study was: (1) to determine the feasibility of this manning constraint and its effect on system availability and an operational and maintenance workload; and (2) to identify areas where SEAFIRE and the Mk 86 GFCS maintainability design could impact on maintenance workload and manning requirements

Not Available. NRAC Study Group 1980. (1980).

Executive Summary

The human element has become the most critical, most problematic and most costly-component of the Navy. Meanwhile, increasingly complex hardware systems are being developed and procured for fleet uses

Given present trends, the Navy will find itself unable to operate and maintain its systems, in either the short or long term, with the numbers-of skilled personnel necessary for effective mission accomplishment.

Clearly, no single solution exists for a problem of this complexity. Many of the conditions are not under the Navy's control. It is also clear that the Navy must maximize the use of the people resources available to it. To achieve this, the equipment and systems in the fleet must be designed to match the characteristics of the people who will be available and must be trained to operate and maintain them. There is considerable evidence that this objective is not being achieved!

Office of Research and Development- USMARAD, Office of Merchant Marine Safety- USCG. Merchant Marine Shipboard Crew Skills and Disciplines Study Phase II F Shipboard Evaluation - Analysis of Specialized Cargo Vessel Design and Personnel Requirements. (February 1976) .

Abstract: This is the report of Phase II F of the Merchant Marine Crew Skills and Disciplines Study. The overall purpose of the study, a continuing effort of MARAD, is to determine manpower and skills required to operate and maintain modern and advanced technology (10 year time frame) cargo vessels. The purpose of Phase II F was to analyze design features and personnel requirements for specialized type vessels employing advanced operating concepts and engaged in the contiguous coastal and Caribbean trade areas carrying small lots of containerized, barge, or neo-bulk cargos between smaller ports and major distribution ports.

Maritime Transportation Research Board. Human Error in Merchant Marine Safety . (1976).

Abstract: This report examines the problem of human error in merchant marine safety. It is organized into two separate parts, with Part I treating the conclusions and recommendations and Part II the supportive information and analytic techniques. The study employs a literature review, a data base evaluation, job descriptions, casualty flow diagrams, and an in-depth survey in its overall analysis. The recommendations are aimed at developing countermeasures against human acts of commission or omission that lead to merchant marine casualties. Recommendations are made in 21 specific areas.

Office of Research and Development- USMARAD, Office of Merchant Marine Safety- USCG. Merchant Marine Shipboard Crew Skills and Disciplines Study Phase II E Shipboard Evaluation of Phase I Findings and Recommendations (Containership). (October 1975) .

Abstract: This is the report of Phase II E of the Merchant Marine Crew Skills and Disciplines Study. The overall purpose of the study, a continuing effort of MARAD, is to determine manpower and skills required to operate and maintain modern and advanced technology (10 year time frame) cargo vessels. The purpose of Phase II E was to evaluate the findings and recommendations of the Phase I study by observation of actual operations aboard a steam-driven containership.

Cherrix, Charles B. and Coffman, Eugene L.. The Evolution of Shipboard Accommodations and Habitability Standards on U.S. Merchant Ships. (October 1975)

Tables and Graphics Only

Office of Research and Development- USMARAD, Office of Merchant Marine Safety- USCG. Merchant Marine Shipboard Crew Skills and Disciplines Study Phase II D Shipboard Evaluation of Phase I Findings and Recommendations (RO-RO/LO-LO with Gas Turbine Plant). (May 1975)

Abstract: This is the report of Phase II D of the Merchant Marine Crew Skills and Disciplines Study. The overall purpose of the study, a continuing effort of MARAD, is to determine manpower and skills required to operate and maintain modern and advanced technology (10 year time frame) cargo vessels. The purpose of Phase II D was to evaluate the findings and recommendations of the Phase I study by observation of actual operations aboard a gas turbine-powered roll-on roll-off/lift-on lift-off (RO-RO/LO-LO) vessel.

The report describes the organization, manning skills, procedures and equipment used to carry out operational, maintenance and administrative functions on board the RO-RO/LO-LO; compares this observed data with data obtained in the Phase I study; and analyzes the impact of the differences noted on the validity of the Phase I findings and recommendations.

Office of Research and Development- USMARAD, Office of Merchant Marine Safety- USCG. Merchant Marine Shipboard Crew Skills and Disciplines Study Phase II B Shipboard Evaluation of Phase I Findings and Recommendations (LASH). (June 1974)

Abstract: This is the report of Phase II B of the Merchant Marine Crew Skills and Disciplines Study. The overall purpose of the study, a continuing effort of MARAD, is to determine manpower and skills required to operate and maintain modern and advanced technology (10 year time frame) cargo vessels. The purpose of Phase II B was to evaluate the findings and recommendations of the Phase I study by observation of actual operations aboard a LASH (Lighter Aboard Ship) vessel engaged on its normal trade route.

The report describes the organization, manning skills, procedures and equipment used to carry out operational, maintenance and administrative functions on board the LASH vessel; compares this observed data with data obtained in the Phase I study; and analyzes the impact of the differences noted on the validity of the Phase I findings and recommendations.

Office of Research and Development- USMARAD, Office of Merchant Marine Safety- USCG. Merchant Marine Shipboard Crew Skills and Disciplines Study Phase II C Shipboard Evaluation of Phase I Findings and Recommendations (Ore/Dry-Bulk Carrier with Unattended Diesel Plant). (December 1974).

Abstract: This is the report of Phase II C of the Merchant Marine Crew Skills and Disciplines Study. The overall purpose of the study, a continuing effort of MARAD, is to determine manpower and skills required to operate and maintain modern and advanced technology (10 year time frame) cargo vessels. The purpose of Phase II C was to evaluate the findings and recommendations of the Phase I study by observation of actual operations aboard a diesel-

powered ore/dry-bulk carrier. The vessel on which observations were conducted is the first U.S. flag merchant ship to be certified for unattended engineroom operation and is manned by a crew of 22.

The report describes the organization, manning skills, procedures and equipment used to carry out operational, maintenance and administrative functions on board the ore/dry-bulk carrier; compares this observed data with data obtained in the Phase I study; and analyzes the impact of the differences noted on the validity of the Phase I findings and recommendations.

Office of Research and Development- USMARAD, Office of Merchant Marine Safety- USCG. Merchant Marine Shipboard Crew Skills and Disciplines Study Phase II A- Shipboard Evaluation of Phase I Findings and Recommendations (Tanker). (March 1973)

Abstract: This is the report of Phase II A of the Merchant Marine Crew Skills and Disciplines Study. The overall purpose of the study, a continuing effort of MARAD, is to determine manpower and skills required to operate and maintain modern and advanced technology (10 year time frame) cargo vessels. The purpose of Phase II A was to evaluate the findings and recommendations of the Phase I study by observation of actual operations aboard a tanker engaged on its normal trade route.

The report describes the organization, manning skills, procedures and equipment used to carry out operational, maintenance and administrative functions on board the tanker; compares this observed data with data obtained in the Phase I study; and analyzes the impact of the differences noted on the validity of the Phase I findings and recommendations. the executive Summary and the basic report are combined in one volume.

Fagan, R., Kelly, R, and Viele J. (The Stanwick Corporation) for the Office of Research and Development- USMARAD, and the Office of Merchant Marine Safety- USCG. Merchant Marine Shipboard Crew Skills and Disciplines Study Vol. 1 Executive Summary. (December 1971).

Abstract: The results of a study to determine manpower and skills required to operate and maintain modern technology (10 year time frame) cargo vessels. Among the principal findings are: (1) present manning and crew skills do not match functional requirements of modern cargo vessels, (2) upgrading of skills and cross-utilization of personnel would allow safe, efficient operation with approximately 50% of present manning, (3) advanced technology ships can be operated by small crews but will require greater technical skill and operating proficiency, (4) present preventative maintenance programs are inadequate, and (5) many shipboard functions could be performed more efficiently and economically by shoreside personnel. The study provides recommended manning, skill levels, crew structures, operating procedures, design modifications, and changes in shoreside logistic support for five types of modern cargo vessels with three types of automated engineering plants. New crew skills required and recommended training methods are presented. Problems that may arise in the implementation of study recommendations, including requirements for modification of existing maritime laws or regulations, are identified. The report is in two volumes: Volume I - Executive Summary, and Volume II - Manning and Skill Requirements (Task I) Design Modifications (Task II), Implementation Problems (Task III), and Legislative Modifications (Task IV).

Office of Research and Development- USMARAD, Office of Merchant Marine Safety- USCG. Merchant Marine Shipboard Crew Skills and Disciplines Study Vol. 2 Task I - Task IV. (December 1971)

Abstract: The results of a study to determine manpower and skills required to operate and maintain modern technology (10 year time frame) cargo vessels. Among the principal findings are: (1) present manning and crew skills do not match functional requirements of modern cargo vessels, (2) upgrading of skills and cross-utilization of personnel would allow safe, efficient operation with approximately 50% of present manning, (3) advanced technology ships can be operated by small crews but will require greater technical skill and operating proficiency, (4) present preventative maintenance programs are inadequate, and (5) many shipboard functions could be performed more efficiently and economically by shoreside personnel.

Norden Division United Aircraft Corporation for MARAD. Merchant Ship Automation Study - Summary and Recommendations (262 R 0011). (April 1961).

"The scope of the feasibility study involved not only the technical aspects, but economics, legal, and labor-management. A basic objective was to recommend the orderly steps that should be taken leading to the fullest possible use of automated devices. Automated equipment or techniques must all be measured by the yardstick of economics. Automation for the pure sake of it is not only unjustified, but could work against the economic objective."

"The method that has resulted in producing the greatest number of major technological advancements and breakthroughs in the last decade is the 'systems approach' method."

"Early in the program Norden recognized that only through complete automation of ship's controls could a significant breakthrough be achieved in accomplishment of the economic objective. Because of the high salaries, extensive fringe benefits, and costly hotel services demanded by a crew, the crew must be minimized."

Used a C-4 Mariner dry-cargo class (fast, 20-knot, steam propulsion system of 17,500 SHP (nominal)) for baseline comparisons.

Norden Division United Aircraft Corporation for MARAD. Merchant Ship Automation Study - Economic Aspects of Automation   (262 R 0017). (April 1961).

Abstract: This volume is comprised of two parts, Part A and Part B. Part A compares the potential commercial benefit of various proposed shipboard automation applications, it also call the attention to the more profitable areas of further research and development. Part B describes the aspects of subsidy and incentive.

The principal aim of this report, then is to examine methods whereby the subsidized operator and seaman may be given strong incentives to adopt shipboard automation. Frequently, however, it treats the problem in its broader framework, which is to overcome the subsidy law's enervating influence on technical progress in general. It is in the latter connection that Maritime Administration accounting procedures are dealt with in the final section of the report. Suggestions are made which could strengthen the economic position of the subsidized merchant marine and give added incentives to improve profitability.

Norden Division United Aircraft Corporation for MARAD. Merchant Ship Automation Study - Legal Implications of Automation   (262 R 0018). (April 1961) .

"Basically, the legal implications arising from the operation of an automated merchant vessel fall roughly into two broad categories. The first category encompasses what we might consider purely operational problems, and the second related to ancillary questions raised by the operation of an automated vessel. The degree of automation ultimately achieved significantly affects each of these categories. It is clear, for example that a ship operated with a complement of two-thirds of what now is required raises problems vastly different from a ship operated with no crew at all."

"Operational problems are those significantly related to the navigation, construction, and manning of the ship. They are functional in nature. Such operational of functional problems involve, for example, the ability of the automated vessel to conform and adapt to the statutory Rules of the Road or its ability to comply with inspection requirements of the United States Coast Guard or of the Federal Communications Commission or other cognizant bodies having jurisdiction over vessels engaged in commerce."

"The second broad category to be considered in this paper includes important but ancillary questions. These questions do not relate to the operation of the automated vessel but to the consequences of such operation. Most of the conventional areas of admiralty law would be affected by the operation of an automated vessel. As we shall see, questions in connection with marine insurance, carriage of goods, general average, salvage, recovery for death and injury, and limitation of liability must be examined in the light of automated merchant ship operation. However, matters not basically affected by automated operation, such as the nature and priority of maritime liens, ship mortgages, jurisdiction of admiralty causes, and the rights of harborworkers are not discussed herein, although they are usually considered in standard maritime texts."

Kahn, A.. Behavioral Analysis of Management Actions in Aircraft Accidents.

Analysis will show that the distal factors of the specific accident are related to the management actions by the reinforcement history of the individuals or groups involved.

Discusses:

- Air Florida Management decisions/behaviors that led to the Flight 90 Accident

- Downeast Flight 46 accident and decisions of owner contributing to accident (reinforcement theory)

- Small plane accident

- Clapham Junction Railway accident

Appendix C - Literature Search Results

Paetow, K.. "Ship of the Future" from Society of Naval Architects and Marine Engineers.

Abstract: In 1980 work began on one of the most intensive and comprehensive marine research and development projects - the German Ship of the Future. Main task was the reduction of the operation costs of a vessel. After five years of work the project was successfully finished with the maiden voyage of the first SdZ prototype ship.

The paper describes first the R+D project itself. The organizational structure, the financial background and some examples of development topics are explained.

The second part is dealing with the conversion of the outcomes of the R+D project into the reality of a containership.

The third part gives by example of some focal points of the newly developed ship service technique a broad description of the HDW-SdZ prototype ships and their economy. A short outlook to further developments closes the presentation.

McAlister, Keith . "A case for automation" .

"Ship operators agree that their survival depends upon cutting costs. There is, however, considerably less unanimity on what are the best means of reaching that goal."

"...two distinct strategies among operators. One follows a high-technology route is based on a balance between an investment technology and the return on investment in the form of higher efficiency, reduced crew, lower fuel consumption and improved maintenance."

Weiler, Daniel J. . "Manning & Human Factors Panel; Summary Report". .

Although the zero manned ship concept is technically feasible, the ship designed to operate in the 2000-2020 time frame will, more likely, be operated and maintained by a smaller crew than that on present day ships. However, along with a reduction in number comes a requirement for greater consideration of the human factors in terms if design improvements, the need for highly skilled, highly trained personnel, and the necessity to effect changes in the support structure including shore logistics, training philosophy, maritime training facilities, collective bargaining agreements, etc.

Froese, J. Hamburg Polytechnic School for Maritime Studies, Hamburg, West Germany, for Society of Naval Architects and Marine Engineers. Current Development in Federal Republic of Germany Regarding Crew Reduction and Bridge Automation.

Abstract: Shipping in the Federal Republic of Germany (FRG), as in most other highly developed traditional shipping countries, is in a depressed state.Owners try to improve economy by changing their flag. Measures able to stop this trend and to allow profitable ship operation under the flag of the FRG are described. As it has been found that it is mainly crew costs that influence international competitiveness they become a target of cost saving measures. A new crew concept, the nucleus crew, is explained. Besides this, integration of deck and engine room officers and one-man-manning on the bridge at night (without additional lookout) are further ideas to reduce personnel costs. The paper ends with the state of the art of new techniques to improve a vessel's efficiency applied in the FRG

http://www.uscg.mil/hq/g-m/nmc/pubs/msm/vol3.htm. Marine safety manual web site. . Marine Safety Manual web page http://www.uscg.mil/hq/g-m/nmc/pubs/msm/vol3.htm

Guidance Chart of Key Parameters of Human Elements Against Typical Emergency Situations.. . This deliverable has been produced in order to increase the general understanding of persons involved in the maritime industry to the important factors affecting the behaviour of those involved in an emergency situation on board any vessel. The document contains a matrix with various emergency scenarios each indicating the factors of importance in the situation.

Contributors: Cetemar, Barcelona, SPAIN; Cetena S.p.A, Genova, ITALY; Danaos Shipping Co. Ltd., Athens, GREECE; Helintec S.A., Athens, GREECE; ISL., Bremen, Germany; Marconsult, Genova, ITALY; University of Strathclyde, Glasgow, UK

Hand Book on "Multi-Cultural" Crews In Emergency Situations. . The use of "multi-cultural" and "multi-national" crews aboard ships is becoming more common and frequent World-wide. The use of these crews can lead to many unforeseen problems due purely to the different cultural backgrounds. Many of the problems associated with the operation of a ship with a "multi-cultural" crew are obvious, for example the problems of different languages. Some problems, however, are subtler, for example different body language or facial expressions, which require closer inspection to be identified or appreciated. The most affected aspect of the ship by the use of these crews is the safety. In particular, the consequences on the people, ship and environment are of concern when considering an emergency. Increased stress and workload will exaggerate the problems found with the use of "multicultural" crews, and hence reduce the safety.

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Norwegian Coast Guard. Knordap class vessel

Missions:

- SAR
- Fisheries inspection (up to 30 inspections a day)
- Law enforcement
- Escort (wartime mission)

3 people interviewed for Norway's Coast Guard:

- CAPT Arind Skram
- CDR Erickson Knordap class project officer
- CDR Nilsen Deck officer/command experience.

General points and comments:

- Manning not reduced, but mission areas expanded - manning held constant.
- Norway has always run ships with reduced people.
- Norwegian CG separate from Norwegian Navy
- Officers take part in work (line handling, maintenance, etc.)
- Officers and ratings have delegated authority to take action (for example, initiate CM actions without chain of command approval)
- Knordap class has experience operating since mid 1980's
- Plan figure for ship is 300 days at sea per year
- Have two boats to deploy to do inspections, SAR, etc.
- Have found that some mission combinations are not possible with initial crew size, so crew size was increased by about 5 people.
- Average age of crew estimated to be about 30 to 35 for officers/PO's, and 18 to 30 for rates.

Watch rotations:

- 4 on / 8 off rotation for watchstanders (normal rotation)
- 6 on / 6 off on, or 4 and 4 occasionally, as conditions/evolutions dictate.

Crew size and characteristics:

- Two crews per ship
- 3 weeks at sea, then crew is changed. Crew changes takes 36 in-port hours.
- Norway finds that 3 weeks at sea, then 3 weeks ashore leads to high crew effectiveness and reduced fatigue.

- 50+ including air complement
- Air complement is 4 people, for operations and maintenance. Air wing attached to Norway Air Force.
- Have increased size of crew "a little bit" to meet workload needs for simultaneous operations.
- Have increased from 17 officers (and PO's) to 22.
- PO's wield authority similar to officers, and can make and implement significant decisions

Quality of life at sea:

- Support organization ashore (integrated with Norway's Navy shore infrastructure)
- One crewman assigned to do laundry and general hab spaces cleaning
- Two person cabins for ratings
- Two person cabins for officers. Generally one officer to a cabin

Fatigue:

- No formal measurement methods
- Just 3 weeks at sea avoids much fatigue

Typical crew workday:

- 10 to 16 hours a day.
- Some workdays up to 20 hours for special evolutions. (fisheries inspections for example)
- 13 hours per day is a good average estimate (CAPT Skram).

Maintenance:

- Major maintenance done in port
- Trend is to have ships crew perform more complex maintenance at sea. This is due to experience with most maintenance done in port: more maintenance was needed, and since the ship is at sea so much, more maintenance is needed at sea.

Cost:

- Average operating cost per year is approximately $20,000 a day, for a two crew vessel (for everything, crew, fuel, training, weapons, etc.)
- Cost of automation couldn't be ascertained by the participants. [Paraphrasing] "Too difficult, the cost data all rolled up in total acquisition costs."

Automation:

- Automation is currently being upgraded (engineering and electrical departments)

- Purdy report discusses automation applications more specifically, and we were referred to the Purdy report.

Training:

- Rates trained mostly by civilian schools.
- Some special ship specific training provided for rates.
- Lots of OJT for rates and officers.

Canadian Coast Guard. Several ship classes

- Type 600 Large Cutter (20 crew) 3,700 tons displacement
- Type 500 Medium Cutter (approx 18 crew) 3,300 tons displacement
- Type 400 Small Cuter (5 crew) 97 tons displacement

<u>Missions:</u>

- SAR
- Fisheries inspection
- Law enforcement

<u>General points and comments:</u>

- Phil Murdock was technical POC
- Union crew at ratings. Officers are Union too.
- For law enforcement, carry a Canadian law enforcement authority to make arrests, etc.
- Most maintenance done by shore support
- Vessels classified under the Canada Shipping Act
- Rates assigned permanently to a ship
- Officers employed in a labor pool, rotate from ship to ship. Normal assignment is 2 to 4 years.
- Ships don't sail short of complement
- Ships minimally manned, can't handle numerous missions simultaneously
- Ergonomic/design for operability (centralized control stations for many functions
- Deployments vary from days on cutters to weeks on icebreakers

<u>Watch rotations:</u>

- View unmanned engine spaces as unsatisfactory. Minimum of 2 people in engineering spaces at all times.
- Generally a three watch system is followed.

<u>Crew size:</u>

- One crew per ship
- Occasionally carry officer cadets
- New type 1000 Icebreaker (Crew size of about 18) - a 50% reduction from previous design.
- Type 600 Large Cutter (20 crew)
- Type 500 Medium Cutter (approx 18 crew)
- Type 400 Small Cuter (5 crew)

Quality of life at sea:

- Per union agreements and collective bargaining.
- All laundry is done ashore by a contractor
- Daily cabin service to officers
- Cafeteria style messing (3 personnel, chief cook, assistant cook, steward)
- Crew/officers share dining area

Fatigue:

- Not formally measured.
- Rely on Union Reps to make a case for fatigue.
- Rely on self reporting and CO/XO observations

Typical crew workday:

- 12 hours

Maintenance:

- Use a standard PMS system.
- There is an amount of condition based maintenance
- Use a lot of in ship redundancy to avoid at sea maintenance
- Have an advance alarm and monitoring system.
- Rarely carry a maintenance rider.
- Use advanced coatings on the hull

Cost:

- Data provided for total crew costs as expressed in spreadsheets (billet lists and cost categories).

Automation:

- Bridge autopilot
- Automated charting (maintain a paper record)
- Automatic monitoring of systems
- Local telephone exchange
- Hand held UHF radios for internal communications
- Automated radar systems (plots, CPA computation)

- Advanced engineering monitoring systems
- Networks aboard some ships
- E-mail/WAN access (Sat-A and M-SAT)
- NIRANDA as a davit mechanism to deploy boats (3 people to operate) (Type 600)
- Self tensioning winches
- Automated weather communications system
- Stern launch ramp for Zodiacs - two people to deploy and recover (Type 400)

Training:

- Rates trained mostly by civilian schools.
- Officers trained completely by the CCG.

Swedish Coast Guard. KBV 181 Class High endurance cutter. 830 tons displacement

Missions:

- SAR
- Boarder patrol
- Environmental protection
- Law enforcement, anti terrorism missions carry extra crewmember.

Three people interviewed for Sweden's Coast Guard:

- CAPT Dan Thorell
- Commodore Stephan Kvarnstrom, Chief of operations
- Bjorne Fago, a ships engineer

General points and comments:

- Four Swedish CG regions. Mission planning is done ashore in one of the regions.
- Personnel represent the highest cost to the Swedish CG.
- Ship built in Finland. Similar Finnish ship has a crew of 18 (the Fins have some military missions that the 181 does not have)
- Swedish CG has "always had reduced number of crew" due to cost effectiveness.
- Boat manning boarding party of 3
- Time at sea about 7 days
- Ship at sea 24 out of 28 days
- No helicopter system
- Ship at sea 80% of the time.
- Dry dock overhaul every 5 years
- Damage control are all-hands evolutions
- CG is a Civilian organization, under the Swedish Ministry of Defense
- Period of assignment to a ship: no officers assigned permanently to a specific ship type.
- New class of Swedish cutter will have crew of 9 with a two watch system. Mission requirements will be the same. Watch system will be 3 hours on, and 3 hours off. Ship will be at sea for 5 day deployments.

Watch rotations:

- Two crews per ship
- Periods at sea: about 7 days, followed by one week at home.
- Three watch system. 3 hours on watch -- 3 hours on standby for boat or special operations -- 3 hours off.
- On watch: 1 Mate, 1 engineer, 1 deck officer each watch

- Engine room unmanned. Engineer stands watch on bridge.
- Master does not stand watch
- Three hours on watch, then three hours standby, three hours free (verified in tapes)
- Maintenance riders on occasion, for corrective maintenance.

Crew size:

- Eleven - all officers (except the cook - steward)
  - One master
  - Three mates
  - Three engineering officers (one is chief engineer)
  - Three deck officer
  - One cook steward

Quality of life at sea:

- Single cabins for all crew
- Food service in larger vessels. Small vessels, crew cooks own food
- Crew takes care of personnel laundry
- Sauna, gym provided
- Recreation area (VCR, etc.) provided

Fatigue:

- No formal mechanisms for measuring fatigue.
- Problems of fatigue not encountered.

Typical crew workday:

- Typical work month: 10 days at work, 18 days off
- 14 hour work day, 10 hours rest
- Messing, training etc. included as part of 14 hour workday.

Maintenance:

- Major maintenance performed ashore, by contractor personnel.
- Routine and corrective maintenance performed by standby engineer
- Major maintenance activities are planned ashore.

Cost:

- Not much cost data available, costs nested in total ship design and construction costs.
- It was estimated that high automation to reduce crewing levels would increase the acquisition cost of a ship by approximately 20% over a traditional approach
- Swedish have to add 36% to mariners pay for social programs and tax (including their coast guard)
- $65k per mariner per year (average, salary and 36% payroll tax, no other overhead items included in that figure)

Automation:

- Engineering systems monitoring from bridge. Chief engineer on bridge. Standby engineer performs maintenance.
- Engineering data are automatically recorded (AMOS system, by SpecTech). System also schedules and triggers maintenance, including print-out of maintenance actions to be performed.
- Remote control and monitoring systems. Can stop and start engineering systems from bridge.
- Fuel system, gears, major equipment controlled from the bridge.
- Advanced alarms system provided.
- Automated record keeping
- Automated position plotting (charting) systems/GPS.
- Mostly commercial equipment used as part of automation.
- Mobile telephones/wireless internal communications.
- Video cameras strategically positioned around ship for viewing in bridge
- Automated fire fighting system in specific areas (in future ship, not on the 181)

Training:

- Officers have 2.5 years training (general), then can go to sea as an officer.
- Merchant Navy experience can count towards the 2.5 years training.
- Special training for: special mission areas (divers, damage control, etc.), engineering, and Masters school
- Each crewmember has ship specific training (e.g., training by class).
- Cost of training borne by the Swedish Coast Guard.
- Crew certification under Swedish rules. These are very close to the IMO rules.

French Navy. French Navy Surveillance Frigates (Type A 69 Class).

Missions:

- The first programs to benefit from this development, as early as the late 1980's, were the class of frigates designed to replace the former escort frigates (AE) for overseas missions.
- Area surveillance
- Escort
- Anti-ship, anti-air, anti-submarine warefare

People interviewed. Zero people interviewed for French Coast Guard. Information was collected via telephone calls and written correspondence. Due to work schedules of the representative of the French Navy (FN), interview forms were provided and FN representative generated a response and submitted that to the FN liaison office in Washington DC. The documents were then translated at the French Embassy and provided to the USCG.

General points and comments:

- Surveillance frigates are ships designed to operate overseas, far away from their home port, to carry out missions of presence, sovereignty (control of exclusive economic zones, navigation policing, fishing surveillance) in zones of limited risks.
- Non air-capable
- The current financial constraints, the professionalization and the new developments in material and equipment in terms of automation and reliability led the French Navy to look for major crew reductions aboard ships.
- They have replaced the former escort frigates (AE) of the (Commandant Riviere) class.
- They are equipped with rustic but durable equipment and boast a wide autonomy.
- They were built by the civilian shipbuilding company (Chantiers de I'Atlantique) in Saint Nazaire according to civilian specifications.
- Given that the French Armed Forces are going to be completely professionalized, there will only be enlisted (volunteer) personnel on board, the draftees being replaced by the same number of enlisted personnel.
- These frigates am equipped with MM 3 8 missiles, a 100 mm gun and a Panther helicopter.
- They are propelled by 4 Semt-Pielstick diesels, which allows a maximum speed of 20 knots. They can be refueled at sea with full or partial shipload.
- Contrary to other navies, the composition of the crew aboard a FN ship is not modified according to the mission of the ship, whether she be at sea or at the pier undergoing maintenance.
- Generally, French Navy crews are smaller than other navies' crews, given the same tonnage.

- Crew reductions are unavoidable given the current and future financial constraints. It is linked to the concept of global ownership cost throughout the life of the ship, which automatically takes into account the human cost through operating expenses.
- Several studies on crew reductions have been conducted in the past; however, these studies have not been implemented, probably because the implementation costs had not, until then, been considered a sufficiently important issue within the French Navy, as opposed to the commercial fleet, but also because automated systems were considered at first less dependable than personnel. The proposals drawn from these previous studies were met rapidly with resistance due to customs, mentalities and a whole culture, while the absence of major constraints did not call for a change.
- For the future surface ships, the French Navy is currently considering further reductions, since the number of 180 has been decided for the tripartite anti-aircraft (Horizon) frigate with a displacement of about 6500 tons, as well as for the NTCD which should be approximately 1/3 larger than the SIROCO (220 men).
- Studies led the FN to set up structures designed to take into account the human factor in the armament programs, with specialists who work in close collaboration with teams responsible for developing programs as well as with industrialists.
- Beyond the man-machine relations associated with technical considerations, we are studying the unavoidable implications which will result from these on board reductions in terms of:
  - change of trades: emergence of new specialties (information, prevention, etc); greater polyvalence of personnel, made easier by the user friendly monitoring and control stations (standardized consoles, etc); new developments in maintenance.
  - internal organization, due in particular to the evolution of the decision-making process (network systems, decentralization, delegation, veto, . . .);
  - individual and collective behaviors, particularly in situation of great constraint, but also associated with the evolution of society : the ships that we are developing will be staffed with young people of our children’s generation, with all the differences that this implies;
  - Man’s status in a more integrated and automated technical environment.
- These necessary and, for the most part unavoidable evolutions are therefore likely to result in major technical and cultural developments within the Navy. However, the fleet will always be made up of ships of very diverse generations, aboard which the same sailors will serve. In order not to create too many differences or even discontinuity among these crews who constitute the bulk of our wealth, it is likely that the introduction of these new measures will take place progressively, in keeping with the building of new ships.

  In conclusion, we are confronted again with a type of challenge which was already the challenge of ((Modem Times)) -- our progress, whatever it may be, will be positive only if we are capable of keeping Man’s true place which is to have machines at his disposal rather than the opposite.

Appendix D - Summary of Work Reducing Approaches

Crew size:

- The surveillance frigates (FS), developed and built by the St Nazaire civilian shipyards, averaging some 3000 ton, had a crew limited to 95, while the [previous] escort frigates with a displacement of 2200 tons had more than 160 personnel aboard.
- The frigate of the La Fayette class (FLF), weighing 3500 tons, built according to military standards, has a complement of 140.
- The crew of the surveillance frigate is composed of 97 men, including: - 10 officers, 10 chief petty officers, 19 petty officers, and 39 sailors for the floating platform - 2 officers, I chief petty officer, 6 petty officers for the aviation unit.
- These ships can also transport an additional 25 men commando unit.

Watch rotations (Watch stations provided in response to the interview forms):

- *Combat role*

  Wheelhouse - 6 crew members

  After steering - I crew Member

  Upper bridge - 4 crew members

  Combat information Center - 10 crew members

  Communications center - 2 crew members

  Back-up radio room - 1 crew member

  100 mm artillery - 1 crew member

  MM 3 8 shelter - 1 crew member

  Engine room - 8 crew members

  Damage control team

  Forward area - 16 crew members

  Aft area - 16 crew members (including 4 stretcher bearers trained in the aviation unit and used outside aviation activity)

  Aviation: 7 crew members

  (Note: The differential as opposed to the full manning is made up of personnel without any specific designated battle stations, and the personnel of the aviation unit.)

- *Surveillance and navigation.*

  Wheelhouse: 4 persons (officer of the deck, steersman and engine order telegraph, signalman, watchman and visual target acquisition system (on order, a petty officer rejoins the upper bridge as head of visual defense and the watchman then mans the visual target acquisition system).

  Combat information center 4 crew members (watch officer, surface warfare officer, electronic warfare radio operator/plotting table, air controller)

  Communications room - 1 crew member

Engine room - 4 crew members (engineering officer of the watch, deputy auxiliary machinery officer, deputy power supply officer, damage control officer)

- *Sea and -anchor detail*

  Wheelhouse - 11 crew members

  Steering - 1 crew member

  Combat Information Center - 6 crew members

  Upper bridge - 3 crew members

  Communications center - 3 crew members

  Engine room - 5 crew members

  Technical intervention (engineering) - 4 crew members

  Fore deck - 10 crew members

  Middle deck - 11 crew members

  After deck - 9 crew members

  (The other positions have not been detailed since they are not significant or do not require a specific organization)

<u>Quality of life at sea:</u>

- No Data provided

<u>Fatigue:</u>

- No Data provided

<u>Typical crew workday:</u>

- No Data provided

<u>Maintenance:</u>

- The crew reductions which have been achieved aboard the surveillance frigates, were carried out with the objective of maintenance reduction by the crew, because it was, at the time, the determining factor that had been identified. BUT this concept could only work with the creation ashore of a support team which worked on board, besides the crew, when the ship was due for maintenance without the assistance of heavy industrial resources (as in the case of overhauls). One must also add that contrary to other navies, the French Navy's crews do almost all the ships maintenance as well as the basic maintenance of most of the equipment installed on board.

<u>Cost:</u>

- No Data provided

Automation:

- In the frigates, the size of the crew was determined to operate the ship, knowing that automation would allow to reduce substantially the number of personnel on watch.
- The current analyses have changed the development of automation and of back-up systems, as well as their greater reliability, permit a substantial crew reduction in the area of ship control. One has only to look at the size of the merchant marine crews to be convinced. The current contentious problem lies in the organization of damage control in the battle station: to be able to respond to combat damage lot of personnel is needed, even though war fighting is planned for a single missile impact.
- The current considerations which will be gathered in the project of the ship of the future, center on [these for the upcoming FN ship design]:
  - the development of internal and external communications networks;
  - the automation of the ship's navigation systems: propulsion, energies, fluids, water management, ventilation, stability, maneuver, etc.
  - internal tele-surveillance devices (security and safety), with possible remote monitoring of the ship from the shore.
  - the integrated decks with the same functions as aboard commercial ships, to which visual defense and damage control capabilities should be added;
  - combat security organization (very costly in personnel): use of tele-surveillance, information networks, automations, remote control of intervention, monitoring and operational capabilities maintenance devices following a breakdown;
  - the organization and general ergonomics of operational centers;
  - the enhancement of protective material and coverings (paints,) to limit surface maintenance, which requires a lot of personnel;
  - the enhancement of material and equipment reliability;
  - the improvement of maintainability on board, which can be attained through preliminary studies on conditions for intervention on shipboard material;
  - remote maintenance devices
- personnel instruction and training.

Training:

- The crew is a regular crew, with no additional training required to be assigned on board.

Japanese Coast Guard. OJIKA Class (38 crew, 1,883 tons displacement) and SOYA Class (46 crew and 3,200 tons displacement)

Missions:

- Coastal patrol
- SAR

People interviewed. Zero People interviewed for Japans Coast Guard. Information was collected via telephone calls and via written correspondence (e-mail and fax). Interview forms were provided and representatives of Japans Coast Guard generated a response and submitted that to the USCG.

General points and comments:

- We require that main-propulsion system should have at least two shafts.
- We design for durability depending an how important such the system is an using redundant systems. That's how we secure reliance against system-down time.
- Our ships are different from warships. We do not assume ships damage caused by weapons against ships. Thus stability, subdivision leaking, fire fighting and life saving with our ships basically apply standards and regulation of cargo ships defined by SOLAS
- Additionally, regarding rescue operation , we assume we will operate our ships In stormy weather that ordinary ships try to avoid. JMSA has its own stability criteria (for dynamic stability, static stability, and maximum angles are defined) while a two-compartment standards applies for subdivisions.

Watch rotations:

- 3 watch rotation: each watchstander stands two 4 hours watches per day
- 4 watch rotation: each watchstander stands two 3 hours watches per day plus 2 hours per day for other duties

Crew size:

- SOYA: 38 (CO, XO, 13 deck, 10 engineering, 4 radio, 6 administration, 11 aviation)
- OJIKA: 46 (38 (CO, XO, 16 deck, 12 engineering, 4 radio, 4 administration)

Quality of life at sea:

- UNK

Fatigue:

- UNK

Typical crew workday:

- 8 hours per day

Maintenance:

- JMSA's maintenance for our ship is Intentionally conducted by establishing [ashore] organization to handle maintenance for HQ and individual RMSHQs office.
- We do not have our own maintenance facility facility. We have contractors take care of cases in which only experts conduct maintenance in terms of facility and technical aspects.
- There are two types of maintenance; SPECIAL MAINTENANCE that Is consigned to contractors and includes inspections required by law, and REGULAR MAINTENANCE that Is conducted by crew members. To conduct both types of maintenance, we stop sailing and conduct intensive maintenance for the ships.
- Speaking of installed machinery and tools, we positively promote using less-maintained ones. Also we try to secure enough safety space in the placement of machinery and tools. As for and tools for business, we supply wide-used component parts used by ordinary commercial vessels as much as possible so that we reduce initial cost and improve the ease of part supply.

Cost:

- UNK

Automation:

- UNK

Training:

- UNK

Royal Netherlands Navy. KAREL DOORMAN Class Frigate. The ship is 401 feet long and has twice as many weapons as a 378' cutter. Displacement 3,320 tons (full load).

Ship visited in Norfolk, Virginia on 5 March. Main POC for the visit was CDR Frederick S. Vleer.

Missions:

- Main missions - defense:
  - Escort duties
  - ASW (active and passive sonar)
  - Harpoon antiship missiles
  - Air defense (Oto Melara 120 rpm and vertical launch Seasparrow)
- Main missions - coastal patrol:
  - Fisheries inspections
  - SAR
  - Drug interdiction

General points and comments:

- Four departments
  - Main engineering
  - Support
  - Supply/logistics
  - Operations
- Ship put to sea 120 days a year. Deployments are six months.
- Ships have intermittent seven week stand-down periods where maintenance is performed, crew is trained on shore, crew goes on vacation.
- In stand-down, four ships are moored together, all four are monitored (equipment, security, fire, etc.) from one of the four ships. The surveillance equipment of all four routed to the technical center of the manned ship. The other three ships are unmanned during this period.
- One mechanism to reduce crew is by "Delegation of authority down the line." CO/XO to maintain situation awareness, delegate authority down the line. Once a task is delegated, it is assumed to be performed unless the CO/XO hear otherwise.
- Female serve as crew also, but only if as much as 15% of the crew are female, otherwise, an all male crew sails.
- The CO is expected to accomplish the mission with up to a ten- percent shortfall.
- Ship sized/designed for male/female crew. Dutch have a 20 year history of using females as crew.

- All volunteer crew
- The crew is unionized.
- Ergonomics and human factors were a major aspect of workload reduction by design of spaces and interfaces.
- UnRep capable - bunkering and vert-rep.
- Damage control philosophy is to fight while hurt.
  - Fixed fire patrol uses
  - Separate FF party, DC party, and Weps repair when in Condition I readiness
- In battle conditions, CO/XO establish war fighting and survivability priorities for the Damage Control Officer, who then allocates ships resources to meet command needs. DC officer has authority to make all resource allocation decisions in the event of battle damage. CO/XO conduct war fighting, based on prioritization of mission requirements, threats, and ship capability.
- Limited crew size can saturate crew requirements to meet mission requirements and threats simultaneously.

<u>Watch rotations:</u>

- Watch rotations vary, but generally:
  - Day workers work 8 to 5.
  - Operations Watchstanding is a two watch system. Watch hours modified to provide for massed sleep.
  - Typical operations watch rotation is 7 hour on, 5 off, 5 on, and 7 hours off. This rotation schedule followed to allow for a 7 hour period for sleep.
  - Bridge watch is a three watch system: 4 hours on, 8 hours off.
- The bridge watch consists of an OD, a JOD, a signalman (at aconsole), a dedicated lookout, and a helmsman
- The Tech Center controls the engine room and is manned by four people

<u>Crew size and characteristics:</u>

- Crew size: 170 including flight crew. 155 without flight crew. In-port watch requires crew of 26.
- One crew per ship
- Bridge manning: 5 to 7 personnel (generally five):
  - OOW (command control and navigation duties)
- An optional officer for special evolutions or training
- Signalman
- Optional extra signal man

  - Helmsman (also acts as a lookout)
  - Lookout
- Operations room manning (C4I stuff):
  - Six people on watch at night
  - 20 persons during daytime
  - 40 persons in Condition I
  - at night, only one weapons officer on duty during Condition III
- Technical Center (engineering monitoring stations):
  - 4 persons generally
  - 8 persons during tactical evolutions
- Ship will sail with as few as 90% of Manning Allowance.

<u>Quality of life at sea:</u>

- When deployed off Dutch waters, the ships are generally at-sea Monday through Friday, and in-port for the weekends.
- Berthing:
  - Eight enlisted to a berthing compartment. Compartments are small and cramped (by my experience) but well furnished and nicely done.
  - Four PO's to a berthing compartment - all share one shower.
  - CPO's get a private stateroom
  - Officers share two to a room
  - CO gets his own stateroom
- There are 4 bars aboard. Full bars, (beer and whiskeys). No alcohol before 1700 or after 2400 when at sea, three drink maximum per day, no cover charge, no minimum.
- Stewards are cooks and serve three meals a day.

<u>Fatigue:</u>

- Captain reported no problems with level of workload on these ships.
- No formal mechanisms exist to monitor accrual of crew fatigue. It's up to self reports on the part of the crew, or the chiefs/officers in departments to diagnose fatigue.

<u>Typical crew workday/work week:</u>

- Nominal work week is 38 hours for day workers. Day workers, while at sea, generally work 50 - 55 hours per week (captains estimate).
- Day workers receive overtime pay or compensatory time for hours worked over 38 per week.
- Watchstanders work hours are 38 hours per week in port, and up to 70 hours per week at sea.

Maintenance:

- Major maintenance done in dockyards by contractors. Major includes engine overhauls (major and intermediate).
- Engine room unmanned as a matter of routine (24 hours a day, except when maintenance is being performed or a roving watch is in the space).
- There is a "low-level" maintenance requirement designated to the crew.
- Major ship overhaul every 4 to 6 years.
- Engineering and auxiliaries maintenance employ both reliability and condition based maintenance philosophies.

Cost:

- No cost data were available.

Automation:

- Automation on Bridge (there is very little):
  - Universal communications handsets (UHF, VHF, Sound Powered all integrated)
  - Autopilot
  - LORAN/GPS
- Video Camera's throughout ship to monitor spaces (on other ships of this class, being fitted into the VAN NES real soon now).
- Operations room automation:
  - LAN
  - Lots of data filtering
  - Human interfaces are computer monitors on a client-server network (sonar waterfall display is an exception)
  - Two rows of computers. First row, enlisted to ID, track, and interrogate targets. Second row, weapons officers who make engagement decisions based on information passed to their tactical displays from automated filtering mechanisms and from the enlisted battery)

- Engineering control/Technical center automation:
  - Extensive sensor network on engineering/auxilliaries hardware
  - Extensive remote control of vital equipment equipment (valves, fans, motors, electrical supply, etc.).
  - Summary information displays provided for main/vital systems

- Advanced alarm systems, alarms are prioritized according to criticality.
- A closed circuit TV system will be a retrofit. The CO does not want engine room alarms on the bridge because he wants the OD looking out for the safety of the ship.

<u>Training:</u>

- Crew doesn't cross over departments. "Advanced ships require . . . in-depth knowledge" so crossover is avoided to limit training requirements.
- Officers rotate after a 2 to 3 years period
- Main at sea training cycles:
  - NBC
  - Firefighting skills
  - Damage control

Commercial Maritime ventures (Several Interviews)
US. Merchant Marine Academies - Lancer Class Chips - Steam ships (SeaLand)
SeaLand - Mike Bohlman
Larsen Lines (SeaLand Costa Rica) - Diesel Container ship

Missions:

- Cargo carrying
- Containerized cargo

People interviewed:

- US Merchant Marine Academy - Mike Rodriguez (2^{nd} officer aboard Lancer Class)
- US - SEALAND - Vince Fitzgerald and Mike Bohlman

General points and comments:

- Sustained operations
- Tours at sea approximately 4 months for deck, 3 months for engineers
- Ratings tours about 8 months
- Union hall crewing for rates (except Bosun was permanent, and master and CHENG are semi-permanent)
- Workspaces designed and arranged to reduce work (ergonomic applications)
- SeaLand Liners underway about 90% of the time. Operational 365 days per year
- Rotation: 4 months at sea, 2 months ashore
- Unattended machinery spaces (engineering as a day watch only)
- Use engineering and deck personnel crossover. QMEDs can serve deck functions, for example.
- Small boar operations unusual.
- Much of logistics administrative support and parts ordering is automated.
- Perishables and payroll reports automated
- Procedures and documents moved to electronic form, given shore support to keep documents up-to-date.
- Use of automation is often not used since much manning is dictated by union agreements (minimum work hours for mariners)

Appendix D - Summary of Work Reducing Approaches

<u>Watch rotations:</u>

- Lancer Class
  - 3 watch system. 4 hours on, 8 hours off (sea watches)
  - 8 hours on, 16 hours off (port watches)
  - shore facility (union hall) came aboard in port to stand night watches
  - four people on deck watch at any time: 2 Abs, 1 OS, mate of the watch
  - three people engineering watch: engineer, wiper, oiler
  - one man bridge watch under optimum conditions (daylight, good weather,etc.)
  - Larsen Lines (SeaLand Costa Rica)
  - Unmanned engineering rooms
  - One man bridge watch (day and night)
  - Two man bridge watch (day)
  - Two watch system, six hours on, six hours off.
  - Engineering personnel are day workers

<u>Crew size:</u>

- Union hall crewing for all but Larsen
- Top officers generally do not rotate. Rates and $2^{nd}/3^{rd}$ mates rotate.

- Lancer Class
  - Lancer Class Chips: Crew reduced from 40 to 21
  - Master, chief mate, 2 2^{nd} mates, 3 3^{rd} makes.
  - Personnel reductions achieved by reducing watch standards and general procedural and operating philosophy changes.
- Larsen Lines (SeaLand Costa Rica) - total of 11
  - Master, 1^{st}, 2^{nd} mates (3 deck officers)
  - CHENG, 1^{st} engineer (2 engineering officers)
  - QMEDs
  - Abs (2)
  - Refer Mechanic
  - Cook
  - Steward/messman

<u>Quality life at sea:</u>

- No special provisions.
- Officers get own stateroom

- Rates share, two to a stateroom
- Full gally services (cafeteria style)
- Family (spouses, children, etc.) can go to sea with crew
- State rooms cleaned by steward.

Fatigue:

- Only per STCW regulations (sleep, etc).
- No formal mechanisms for crew fatigue assessment.
- Overtime hours logged. This can be used to compare work hours to STCW requirements

Typical crew workday:

- Per STCW: max 12 hours per day, 10 hours provided for sleep (Mike Rodriquez)
- SeaLand, 8 hour workday, and up to 80 hours overtime allowed per month, or about 76 hours per week. This is per union agreement for length of workweek and paid overtime hours.

Maintenance:

- Larsen Lines (SeaLand Costa Rica)
  - Major maintenance performed by ships crew during port calls
  - Reliability based maintenance schedules
  - Aspects of Condition based maintenance followed (vital systems are heavily machine sensed and monitored)
- Major maintenance done ashore (liners replaces, heads replaced, aux generators rebuilt, etc). Maintenance is deferred until a port call is made, if possible
- Maintenance is scheduled by reliability factors.
- Limited use of automated equipment monitoring for condition based maintenance.
- Engineering maintenance manning for SeaLand: 3 officers, 4 rates.
- Riding crews used to perform some maintenance.

Cost:

- No cost data available.

Automation:

- Larsen Lines (SeaLand Costa Rica)

- advanced sensing and alarming throughout ship
- navigation: GPS, electronic charting,
- communications, internal radio telephones
- administrative, shore supported planning, automated ship-to-shore reporting,
- control, most functions can be controlled from any workstation.
- distributed computing, all vital functions can be controlled from the bridge, including main engine lite-off (diesels) and engine control. Most functions can be performed from any computer workstation location (ballast control, fuel transfer, engineering control, auxiliaries control)
- constant tension winches

- Other SeaLand:
  - No unique damage control automation
  - Given reduced manning, can form two hose teams, but DC is an all hands evolution.
  - Shore facilities provided as technical information centers.
  - Electronic charting *Not* used due to Union agreements.
  - NOAA reporting is automated.

Training:

- Maritime academy training
- Union schools
- Maritime schools
- No ship specific training (just certifications and licenses)
- On board drills frequent (fire, SAR, terrorist attack)
- Simulation training in Maritime schools

British Royal Navy. Type 23 (DUKE Class). 4,200 tons displacement full load.

Missions:

- ASW
- ASUW
- AAW
- Emergency evacuation
- Law enforcement (boarding parties in the gulf)

People interviewed:

- Mr. Patrick Carnie, RN marine engineer and HSI professional.

General points and comments:

- First RN attempt at reduced cost, and reduced manning (15 year history, first completed in 1989).
- Use human factors as first principles: top-down functions analysis.
- Type 23 carries a helicopter
- On one ship the RN carries a 5th watch, an extra 25% of crew (that stay ashore 25% of the time)
- 30 to 40% general ship manning reduction in the RN since the 60's
- Type 23 report was discussed, and was stated to be released directly to the USCG.

Watch rotations:

- Four hours on, 12 hours off (but there was some uncertainty)

Crew size and characteristics:

- Initial complement about 157. Over the years, complement has grown to 181. Growth was due to excessive workload.
- Compare to Type 22 FFG (4,800 tons displacement full load), which has a complement of 273, or a Type 42 DDG (4,100 tons displacement full load) with a manning of 253.
- 13 officers, 168 enlisted
- One crew per vessel
- Females serve as crew. Ships designed to 3% to 97% male anthropometry.

Quality life at sea:

- Due to recent increase in crew size, the ship is at its limits for personnel accommodation.
- Fitness and recreational spaces provided

Fatigue:

- No formal mechanisms to assess crew fatigue.

Typical crew workday:

- UNK, but increase in manning level indicates that workday was long, and workload high, so crew had to be added.

Maintenance:

- There is a lot work on the type 23 in "ship husbandry" (cleaning, chipping, painting, etc.)

Cost:

- Some cost data sent via postal mail. Cost data represented cost of personnel (pay, and primary and secondary overhead)

Automation:

- Damage control and fire-fighting
- Remote cameras used throughout ship
- Automated monitoring, using motion detection technologies as part of video systems
- Some logging and monitoring system, but still it's mainly done manually.

Training:

- UNK

Danish Coast Guard. Thetis Class Frigate. Displacement 3,500 full load.

Missions:

- Fisheries inspection and law enforcement
- ASW
- Mine laying
- Coastal defense
- Ice breaking

People interviewed:

- CDR Hendrick K. Kudsk (telephone interview)
- CAPT Eric Rode (in person interview)

General points and comments:

- Built to military standards only where needed
- CHENG has important deck duties for special evolutions, andis on the bridge during berthing, damage control situations, and close maneuvering operations.
- Use of COTS where possible
- Weapons and electronics of high quality to reduce maintenance
- Use flexible, containerized materials for replenishment of stores
- High degree of automation
- Everyone is engaged in most operational tasks
- High degree of delegation of authority
- In multi-task situations, tasks have to be performed serially, rather than in parallel.
- Quality accommodation standards required to recruit and keep personnel
- Sleep and night and work during the day philosophy.
- Bridge and operations room collocated.
- Fisheries and SAR (peacetime operations) require frequent small boat operations.
- Small Boat operations very similar to USCG, 3 to 4 people on the boat, and four (if a safety observer is present, otherwise three people on the ship) on the ship to handle the davits, winches, and painters (the Danes use for and aft line handlers)
- Ship uses a STANDARD FLEX system, allowing reconfiguration of the ship to meet specific missions. Replaceable modules take 2 to 4 hours to change.

- No automation or procedures implemented to reduce work associated with helicopter operations. The Danish RN doesn't use haul down equipment, rather, negative pitch is placed on the rotors to hold the aircraft to the deck. At that time, deck crew attach tie downs to the helicopter and deck.
- Flex damage control organization:
  - Control is commanded by second engineering officer
  - CHENG is on the bridge
  - Two junior officers and a senior chief lead the DC parties
  - Two damage control parties can be formed
  - Four to six persons in each DC party, supplemented by other ship crew

Watch rotations:

- Engineering watch rotation is 4 hours on and 8 hours off.
- There are three engineering watch stations, the other personnel are day workers.
- Operations room unmanned during normal operations

Crew size and characteristics:

- Two crews per vessel that rotate every two to three months.
- Crew that is off ship have one month leave followed by one month training.
- 60, 12 officers and 48 enlisted (64 with the helicopter attachment)
- 12 spare berths provided for rider crews
- Previous class (NIELS JUEL) has a crew of 94 (15 officers) and a displacement of 1,320 tons full load
- Deployments are nine months
- Most crew work as day workers.
- Mixed gender crews sail these ships

Quality life at sea:

- A very good accommodation standard. Petty officers up to officers get own stateroom.
- Double cabins for ratings.
- All cabins have shower and toilet.
- Gym, crews lounge provided
- Medical services provided with a full hospital (small) manned by a surgeon and an assistant (EMT type). Hospital is provided as part of SAR mission. Hospital has a full operating suite.

Appendix D - Summary of Work Reducing Approaches

Fatigue:

- No formal monitoring tools. CDR Kudsk has not seen an increase in fatigue due to drastically reducing manning.

Typical crew workday:

- 10 hours (officer and rates), up to 16 hours a day for certain evolutions (fisheries inspections for example)
- 8 to 12 hours per day is a good average estimate (CDR Kudsk estimate).

Maintenance:

- Use paint systems that reduce maintenance time.
- Engineering department consists of 4 officers, 2 cadets, and 10 enlisted.
- Advanced monitoring systems used.
- Two watchstanders serve as rovers.
- Time based preventative maintenance system, with reliability data driving the maintenance systems
- Ships crew performs major maintenance actions (such as pulling cylinders on main engine) since the ship is away from home port 9 months out of the year.
- Use hand held VHF radios for in ship comms.

Cost:

- Costs of paints and coatings provided by separate e-mail
- Costs of LANs provided by separate e-mail

Automation:

- Use of advanced coatings
- Advanced communications (telephone and hand held radios)
- High level of bridge automation, including record keeping, ship space monitoring.
- Complete engine control is possible from the bridge.
- LAN is used to control automated systems. Control of technical systems (non-combat systems) can be exercises from the bridge or engineering, using the LAN.
- Advanced sensing and alarm systems employed.
- Space monitoring for fire detection and damage control.

<u>Training:</u>

- Extensive cross training. Personnel utilized as a function of time availability and operational sequence/evolutions. For example, the Danes use cooks as line handlers during docking operations and in support of air operations (tie-downs, fold rotors back, set safety nets and stantions, etc.)
- Basic training in a persons specialty area (engineering, electronics, etc.) is provided at schools. Ships task training (e.g., boat operations, deck operations in support of air operations, etc.) used to cross-train personnel.

US Coast Guard. CGC DEPENDABLE (RELIANCE Class medium endurance cutter). 1,229 tons displacement (full load)

Missions:

- SAR
- Law enforcement
- Defense

People interviewed:

- LCDR Nagle. XO interviewed aboard during a ship visit in Portsmouth Virginia.
- Ad Hoc discussion with several crewmembers.

General points and comments:

- 13 crew removed from the ship as part of a trial personnel reduction effort
- Most workload removed via redesign of procedures
- Attempted to go to a paperless operation, but failed as the required automation was not brought aboard (full time internet access)
- Added computer workstations (three NT servers)
- Objectives were to reduce work and improve quality of life at sea.
- A report on the effort was on the ship in Draft form, but could not be released to this effort (it was still under review)
- Ships meetings were controlled so that meetings did not occur aver 1600.
- Shore support mechanisms did not evolve/develop to support the effort. Was deemed to not have been a problem.

Watch rotations:

- Standard rotations for USCG cutters.
- CCTV allows a five person in port fire watch (night watch), and allows for overall ship surveillance (cost of system as $54K).

Crew size and characteristics:

- Nominal crew was 75. Reduced to 62 for this study (reduction of 13 crew, or 21%). Operated with reduced crew for about a year.
- Dependable has sailed with these work reducing approaches with as few as 45 crew, but workload was too high and fatigue developed in the crew.

<u>Quality life at sea:</u>

- Increased as a result of this effort. Sufficient work was removed to easily allow crew reduction of 13. It was suggested that even with this crew reduction, an overall reduction of workload was achieved for the crew remaining.

<u>Fatigue:</u>

- Not formally monitored or measured.

<u>Typical crew workday:</u>

- 10 to 12 hours

<u>Maintenance:</u>

- Runner carpets added to high traffic deck areas reduces need to clean and replace deck tiles.
- PMS 2000, a maintenance scheduling system, reduced workload by about 20% (estimated value). (Called a"first step towards reliability based maintenance).

<u>Cost:</u>

- Cost of the conveyer system was $400.
- 20% Maintenance manpower cost avoidance via PMS 2000
- CCTV costs $54,000

<u>Automation:</u>

- Wireless ship communications. Practically eliminated use of Sound Powered Phones. (Wireless comms cited as the "single best workload reducer). Cost of 20 Motorola UHF radios was $16,000.
- Fire/smoke/heat sensors in every space, noted as the "Nittran" system. Digital Voice system (a British system called "Akusta") announces throughout ship (a) that a fire is detected or suspected, and (b) the compartment where detected.
- Conveyer system added to support load of stores. Work party size reduced from 16 to 4 people to move stores from topsides to the internals of the ship. Cost of the conveyer system was $400.
- SCCS (Ship Command/Control System) added.
- Electronic charting and navigation system
- GDOC/73 radar
- GPSS
- Closed Caption TV (CCTV) through ship (most spaces).

- PMS 2000, a maintenance scheduling system, reduced workload by about 20% (estimated value). (Called a "first step towards reliability based maintenance").

Training:

- Lots of cross training an utilization of personnel across departments. For example, store keepers and Yns are use as part of boat details, and stand watch as lookouts on the bridge or at the bow.

APPENDIX E

Cutter Reference Crew

Appendix E - Cutter Reference Crew

Cutter Reference Crew - Nominal Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	8	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 106		E5	5	2	1	2	2		1	1	1		1		1	1	1	
		E4	6	2	2	1	2	1	1	2	2		1	1			2	
		E3	3				5			1	1							
		E2	3				5											

Damage Control Strategy - Nominal Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	8	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 104		E5	5	2	1	2	2		1	1	1		1		1	1	1	
		E4	6	2	2	1	2	1	1	2	2		1	1			2	
		E3	3				4			1	1							
		E2	2				5											

Multiple Crewing - Nominal Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	8	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 106		E5	5	2	1	2	2		1	1	1		1		1	1	1	
		E4	6	2	2	1	2	1	1	2	2		1	1			2	
		E3	3				5			1	1							
		E2	3				5											

Risk Acceptance - Nominal Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	2	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	7	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 96		E5	4	2	1	2	1		1	1	1		1		1	1	1	
		E4	5	2	2	1	2	1	1	1	2		1	1			2	
		E3	2				4			1	1							
		E2	2				4											

Appendix E - Cutter Reference Crew

Deck Strategy - Nominal Case																			
Officers		Enlisted																	
O6	1		Eng				Weps			Ops					Admin				
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1												
O3	2	E8	1	1	1			1		1					1				
O2	8	E7				1			1		1					1	1		
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 103		E5	5	2	1	2	2		1	1	1		1		1	1	1		
		E4	6	2	2	1	2	1	1	2	2		1	1			2		
		E3	2				5			1									
		E2	3				4												

Bridge Strategy - Nominal Case																			
Officers		Enlisted																	
O6	1		Eng				Weps			Ops					Admin				
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1												
O3	2	E8	1	1	1			1		1					1				
O2	6	E7				1			1		1					1	1		
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 100		E5	5	2	1	2	2		1	1	1				1	1	1		
		E4	6	2	2	1	2	1	1	1	2			1			2		
		E3	3				5				1								
		E2	3				5												

Appendix E - Cutter Reference Crew

Engineering Strategy - Nominal Case

Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8		1	1			1		1					1			
O2	6	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 97		E5	3	1	1	2	2		1	1	1		1		1	1	1	
		E4	4	2	2	1	2	1	1	2	2		1	1			2	
		E3	2				5			1	1							
		E2	3				5											

Enabling Technologies - Nominal Case

Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	2	E9	1				1											
O3	2	E8		1	1			1		1					1			
O2	5	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 89		E5	3	1	1	2	2		1	1	1				1	1	1	
		E4	4	2	2	1	2	1	1	1	2			1			2	
		E3	2				4				1							
		E2	2				5											

Design for Operability/Maintainability - Nominal Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	2	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	7	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 96		E5	4	2	1	2	1		1	1	1		1		1	1	1	
		E4	5	2	2	1	2	1	1	1	2		1	1			2	
		E3	2				4			1	1							
		E2	2				4											

Cutter Reference Crew - Optimistic Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	8	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 106		E5	5	2	1	2	2		1	1	1		1		1	1	1	
		E4	6	2	2	1	2	1	1	2	2		1	1			2	
		E3	3				5			1	1							
		E2	3				5											

Appendix E - Cutter Reference Crew

Damage Control Strategy - Optimistic Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	8	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 102		E5	5	2	1	2	2		1	1	1		1		1	1	1	
		E4	6	2	1	1	2	1	1	2	2		1	1			2	
		E3	3				4			1	1							
		E2	2				4											

Multiple Crewing - Optimistic Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	8	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 106		E5	5	2	1	2	2		1	1	1		1		1	1	1	
		E4	6	2	2	1	2	1	1	2	2		1	1			2	
		E3	3				5			1	1							
		E2	3				5											

Risk Acceptance - Optimistic Case																		
Officers		Enlisted																
O6			Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	1	E9	1				1											
O3	4	E8	1	1	1			1		1								
O2	6	E7				1			1		1					1	1	
CWO	2	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 86		E5	3	1	1	2	1		1	1	1		1		1	1	1	
		E4	5	2	2	1	2	1	1	1	1						2	
		E3	2				4											
		E2	2				4											

Deck Strategy - Optimistic Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	8	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 102		E5	5	2	1	2	1		1	1	1		1		1	1	1	
		E4	6	2	2	1	2	1	1	2	2		1	1			2	
		E3	2				5			1								
		E2	3				4											

Bridge Strategy - Optimistic Case																		
Officers		Enlisted																
O6			Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	6	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 97		E5	5	2	1	2	2		1	1	1				1	1	1	
		E4	6	2	2	1	2	1	1	1	1			1			2	
		E3	3				5											
		E2	3				5											

Engineering Strategy - Optimistic Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8		1	1			1		1					1			
O2	6	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 94		E5	3	1	1	1	2		1	1	1		1		1	1	1	
		E4	3	1	2	1	2	1	1	2	2		1	1			2	
		E3	2				5			1	1							
		E2	3				5											

Enabling Technologies - Optimistic Case																		
Officers		Enlisted																
O6			Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8		1	1			1		1					1			
O2	6	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 83		E5	3	1	1	1	2		1	1	1				1	1	1	
		E4	3	1	1	1	2	1	1	1	1			1			2	
		E3	2				4											
		E2	2				4											

Design for Operability/Maintainability - Optimistic Case																		
Officers		Enlisted																
O6			Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	1	E9	1				1											
O3	4	E8	1	1	1			1		1								
O2	6	E7				1			1		1					1	1	
CWO	2	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 86		E5	3	1	1	2	1		1	1	1		1		1	1	1	
		E4	5	2	2	1	2	1	1	1	1						2	
		E3	2				4											
		E2	2				4											

Appendix E - Cutter Reference Crew

Cutter Reference Crew - Pessimistic Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	8	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 106		E5	5	2	1	2	2		1	1	1		1		1	1	1	
		E4	6	2	2	1	2	1	1	2	2		1	1			2	
		E3	3				5			1	1							
		E2	3				5											

Damage Control Strategy - Pessimistic Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	8	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 105		E5	5	2	1	2	2		1	1	1		1		1	1	1	
		E4	6	2	2	1	2	1	1	2	2		1	1			2	
		E3	3				5			1	1							
		E2	2				5											

Appendix E - Cutter Reference Crew

Multiple Crewing - Pessimistic Case

Officers		Enlisted																	
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	8	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 106		E5	5	2	1	2	2		1	1	1		1		1	1	1	
		E4	6	2	2	1	2	1	1	2	2		1	1			2	
		E3	3				5			1	1							
		E2	3				5											

Risk Acceptance - Pessimistic Case

Officers		Enlisted																	
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	2	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	8	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 101		E5	5	2	1	2	1		1	1	1		1		1	1	1	
		E4	6	2	2	1	2	1	1	1	2		1	1			2	
		E3	2				5			1	1							
		E2	3				4											

Deck Strategy - Pessimistic Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	8	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 104		E5	5	2	1	2	2		1	1	1		1		1	1	1	
		E4	6	2	2	1	2	1	1	2	2		1	1			2	
		E3	2				5			1	1							
		E2	3				4											

Bridge Strategy - Pessimistic Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	7	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 103		E5	5	2	1	2	2		1	1	1				1	1	1	
		E4	6	2	2	1	2	1	1	2	2			1			2	
		E3	3				5			1	1							
		E2	3				5											

Appendix E - Cutter Reference Crew

Engineering Strategy - Pessimistic Case

Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8		1	1			1		1					1			
O2	7	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 100		E5	3	2	1	2	2		1	1	1		1		1	1	1	
		E4	5	2	2	1	2	1	1	2	2		1	1			2	
		E3	2				5			1	1							
		E2	3				5											

Enabling Technologies

Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	3	E9	1				1											
O3	2	E8		1	1			1		1					1			
O2	7	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 96		E5	3	2	1	2	2		1	1	1				1	1	1	
		E4	5	2	2	1	2	1	1	2	2			1			2	
		E3	2				4			1	1							
		E2	2				5											

Design for Operability/Maintainability - Pessimistic Case																		
Officers		Enlisted																
O6	1		Eng				Weps			Ops					Admin			
O5	1		MK	EM	DC	ET	BM	GM	FT	QM	RM	MST	RD	TT	SK	YN	SS	HS
O4	2	E9	1				1											
O3	2	E8	1	1	1			1		1					1			
O2	8	E7				1			1		1					1	1	
CWO	3	E6	2	1	1	1	1	1	1	1	1	1	1	1			1	1
Total 101		E5	5	2	1	2	1		1	1	1		1		1	1	1	
		E4	6	2	2	1	2	1	1	1	2		1	1			2	
		E3	2				5			1	1							
		E2	3				4											

APPENDIX F

Strategy Implementation Costs

Damage Control Strategy												
Install advanced interior comms, automated fire/smoke detection and alarm system, automated damage control closures, valves, and equipment.												
	Nominal				Pessimistic				Optimistic			
	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period
Advanced Interior Communications (IC) System	320		240	10	500		375	10	140		105	10
Fire/Smoke detection and alarm system	500		375	10	4100		3075	10	35		26.25	10
Automated DC closures and valves	200	5			217	10	100	5	100			
CCTV Monitoring System	(incl abv)				(incl abv)				54		40.5	10

Numeric values in thousands of dollars

Multiple Crews												
Reduce the number of ships required by multiple crewing, i.e. blue/gold crews, 3 crews for 2 ships etc. and running the ships at a higher operational tempo.												
Develop crewing policies and procedures, e.g. crew handoff and Homeporting	Nominal				Pessimistic				Optimistic			
	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period
	6 pers. - 6 mos. + 250				8 pers. - 1 yr. + 500				3 pers. - 6 mos. + 250			

Numeric values in thousands of dollars

Risk Acceptance												
Reduce crew size and accept risks of not being able to respond to low probability emergency events or concurrent multiple mission events.												
Detailed risk/mission analysis to support crew reductions	Nominal				Pessimistic				Optimistic			
	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period
	6 pers. - 1 yr. + 500				10 pers. - 1 yr. + 1000				5 pers. - 6 mos. + 300			

Numeric values in thousands of dollars

Deck Strategy												
Reduce crew workload with automated mooring winches and other advanced deck machinery and by using premium coating systems. Note: Boat handling is a candidate for workload reduction, but no advanced systems with > 3 years proven track record were found.												
	Nominal				Pessimistic				Optimistic			
	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period
Automatic mooring winches	50	5	10	5	100	10	20	5	50		5	5
Automatic anchoring equipment	50	5	10	5	100	10	20	5	50		5	5
Advanced Corrosion Control Systems	100		100	7	200		200	5	50		50	10

Numeric values in thousands of dollars

Bridge Strategy												
Install automated voyage planning, navigation, and ship control systems to reduce operations planning and bridge watchstanding workload.												
Integrated Bridge System	Nominal				Pessimistic				Optimistic			
	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period
	500		375	10	1000	5	750	10	0	0	0	0

Numeric values in thousands of dollars

Engineering Strategy												
Install automated alarm and monitoring equipment, remote and automatically operated machinery and systems and employ techniques such as Condition Based Maintenance to reduce engineering workload.												
	Nominal				Pessimistic				Optimistic			
	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period
Automated monitoring/alarm and machinery control system	2000	10	1500	10	4100	20	2000	10	850	5	640	10
Develop CBM and RCM processes	5 pers. - 1 yr. + 500				10 pers. - 1 yr. + 1000				5 pers. - 6 mos. + 300			

Numeric values in thousands of dollars

Enabling Technologies												
Ship is fitted with automation and technology systems that enable policy/procedural changes. Systems include: LAN, wireless interior comms, bridge automation systems, automated machinery monitoring, alarm and control, and automated damage control.												
	Nominal				Pessimistic				Optimistic			
	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period
LAN	1000	80	150	3	2000	160	400	3	500	40	200	5
Advanced Interior Communications (IC) System	320		240	10	500		375	5	140		105	10
Integrated Bridge System	500		375	10	1000	5	750	10	0	0	0	0
Automated monitoring/alarm and machinery control system	2000	10	1500	10	4100	20	2000	10	850	5	640	10
Fire/Smoke detection and alarm system	500		375	10	Included above				35		26.25	10
Automated DC closures and valves	200	5			217	10	100	5	100			
CCTV Monitoring System	(incl abv)				(incl abv)				54		40.5	10

Numeric values in thousands of dollars

Design for Operability and Maintainability												
Incorporate human factors into the initial design of the cutter.												
Human Factors Engineers involvement in ship design process	Nominal				Pessimistic				Optimistic			
	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period	First Cost	Annual O&M	Periodic Costs	Period
	1000				1500				500			

Numeric values in thousands of dollars